Middle Salmon River-Chamberlain Creek Subbasin Assessment And Crooked Creek Total Maximum Daily Load

Final

Revised December 2002

Prepared by:

Mark L. Shumar
State Technical Services Office
Idaho Department of Environmental Quality
Boise, ID 83706

Acknowledgements: The subbasin assessment was prepared by: Todd Maguire and Mark Shumar. Crooked Creek TMDL was prepared by Mark Shumar, Don Zaroban, & Darcy Sharp. All authors are in the State Technical Services Office, Idaho Department of Environmental Quality, 1410 N. Hilton, Boise, ID 83706. The authors would like to thank for their contributions Nick Gerhardt, J.D. Mays and Gayle Howard of the Nez Perce National Forest, Randy Zuniga of the Payette National Forest, Don Anderson and Al Van Vooren of the Idaho Department of Fish and Game, Daniel Stewart and Bill Clark of the Idaho Department of Environmental Quality, Susan Moore of USGS, and Lorraine Edmond and Peter Leinenbach of USEPA. The authors thank Barry Burnell for his leadership and helpful comments.

CONTENTS

Tables

Maps

Figures

EXECUTIVE SUMMARY

The middle Salmon River – Chamberlain Creek subbsain is located in central Idaho and includes the main Salmon River from the Middle Fork Salmon River to French Creek. This is primarily wilderness country. Major portions of the subbsain are in either the Frank Church River of No Return Wilderness or the Gospel Hump Wilderness. There are eight stream segments that are listed on the 1998 303d list for Idaho. The listed stream segments are located in portions of the subbasin primarily outside of wilderness areas.

Six north-side tributaries of the Salmon River are listed for sediment. These are Big Creek, Crooked Creek, Jersey Creek, Big Mallard Creek, Little Mallard Creek, and Rhett Creek. Additionally, Warren Creek, a south-side tributary to the Salmon River, is listed for habitat alteration from its headwaters to the wilderness boundary. The Salmon River is 303d listed from Corn Creek to Cherry Creek for unknown pollutants.

All listed streams were assessed by Idaho DEQ and determined to be fully supporting their aquatic life uses, with the exception of Crooked Creek. Additionally, north-side streams and the Salmon River were assessed by the Nez Perce National Forest using NEZSED modeling, BOISED modeling information provided by the Payette National Forest, and USGS sediment and streamflow data. The Nez Perce National Forest assessment provides a coarse estimation of sediment yields based on land use coefficients and natural erosion potential. Simulations from this modeling suggest these streams may not produce abundant activity-related sediment, at least not in excess of the model's inherent variability.

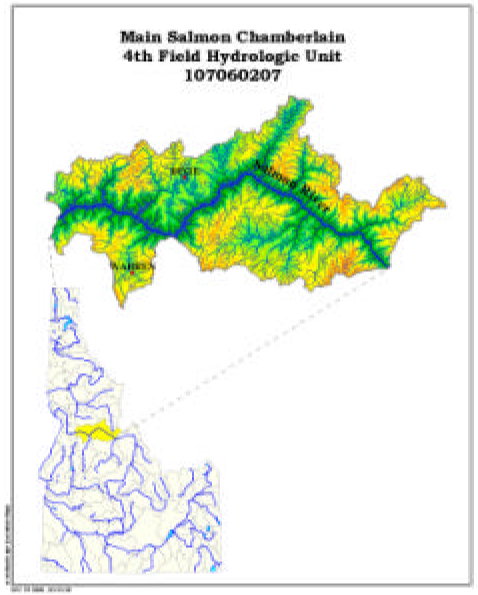
Because all streams are supporting their aquatic life uses and human activity related sediment yields appear to be low, it was determined that none of the streams 303d listed for sediment, including the Salmon River, were sufficiently impacted to require total maximum daily loads for sediment. Warren Creek, is obviously altered by past dredge mining, and is correctly listed for habitat alteration. No total maximum daily load is required for a stream listed for habitat alteration.

During the subbasin assessment, water temperature data indicated the upper portion of Crooked Creek has elevated water temperatures, which may impact salmonid spawning throughout the creek. A total maximum daily load (TMDL) for temperature in Crooked Creek was calculated based on effective shade modeling. This TMDL suggests water temperatures need to decrease and effective shade needs to increase in upper Crooked Creek to achieve a natural water temperature regime. Effective shade modeling suggests Crooked Creek should have thermal loads that vary from 60 to 300 Langleys/day and effective shade from 50 to 90%. Existing canopy coverage was used to identify problem areas that may lack effective shade and have increased solar loading in upper Crooked Creek.

Mid-Salmon/Chamberlain Subbasin at a Glance

IDEQ 1998 303(d) List
Mid-Salmon/Chamberlain Subbasin Hydrological Unit Code # 17060207

WQLS	Assessment Units of ID17060207	Waterbody	Boundaries	Year of TMDL	Pollutants			Stream Miles
3346	SL001_07, SL008_07, SL018_07, SL037_07	Salmon River	Corn Creek to Cherry Creek	2000			Unknown	76.9
3349	SL067_05, SL068_02, SL068_03, SL068_04	Crooked Creek	Headwaters to Salmon River	2000		Sediment		21.25
3351	SL069_02, SL069_03	Big Creek	Headwaters to Crooked Creek	2000		Sediment		12.25
3352	SL007_02, SL007_03, SL007_03a	Warren Creek	Headwaters to Wilderness boundary	2000	Habitat Alteration			16.15
5018	SL061_02, SL061_02a	Big Mallard Creek	Headwaters to Salmon River	2000		Sediment		18.77
5099	SL065_02	Jersey Creek	Headwaters to Salmon River	2000		Sediment		7.65
5109	SL062_02	Little Mallard Creek	Headwaters to Salmon River	2000		Sediment		8.78
5156	SL063_03	Rhett Creek	Headwaters to Salmon River	2000		Sediment		8.39



Changes for 303(d) List
Based on Mid-Salmon/Chamberlain subbasin assessment
(Changes in bolded italics)

Waterbody	Boundaries	Year of TMDL	Pollutant			Stream Miles
Salmon River	Corn Creek to Cherry Creek	2000			***De-list Unknown***	76.9
Crooked Creek	Headwaters to Salmon River	2000		***De-list Sediment***	***Add Temperature***	21.25
Big Creek	Headwaters to Crooked Creek	2000		***De-list Sediment***		12.25
Warren Creek	Headwaters to Wilderness boundary	2000	Habitat Alteration			16.15
Big Mallard Creek	Headwaters to Salmon River	2000		***De-list Sediment***		18.77
Jersey Creek	Headwaters to Salmon River	2000		***De-list Sediment***		7.65
Little Mallard Creek	Headwaters to Salmon River	2000		***De-list Sediment***		8.78
Rhett Creek	Headwaters to Salmon River	2000		***De-list Sediment***		8.39

Hydrologic Unit Code	17060207
Primary drainage	Main Salmon River
Listed stream miles	170.14
Beneficial Uses Affected	Cold water biota Salmonid spawning
Species of Concern	Chinook Salmon, Steelhead Trout, Bull Trout, Westslope Cutthroat Trout
Population	Less than 100
Major land uses	Forestry, rangeland and recreation
Public participation	1/17/2001 – 2/19/2001 Two agencies and one tribe responded

Crooked Creek at a Glance

1998 303(d) listed stream miles	21.25
Geomorphic characteristics	Third order stream Rosgen B Channel
Salmonid spawning	Multiple age classes above and below migration barrier; bull trout observed below barrier
Cold water biota	Macroinvertebrate index scores = 4.92(lower), 4.46(upper)
Impacts to riparian area	Placer and dredge mining in upper watershed

Listing History

- Crooked Creek was placed on the State of Idaho 303(d) list in 1996 by EPA, it was retained on the 1998 list due to a lack of information.

Waterbody Assessments

- BURP
  - 1997SLEWC011 MBI 4.92, fines 30%, w/d ratio 36.7
  - 1997SLEWC016 MBI 4.46, fines 18%, w/d ratio 21.6
- NPNF
  - Sediment yield 4.4% over base for CEW, 0.7% lower Crooked Cr., 24% upper Crooked Cr.
  - Temperature exceed criteria for salmonid spawning and bull trout.

Recommendations and Conclusions

- Crooked Creek was listed for sediment. However, good macroinvertebrate scores and low sediment yield overall indicated that the stream should be de-listed for sediment. Temperature criteria violations led to TMDL for temperature. An increase in canopy coverage is needed in upper Crooked Creek watershed to correct water temperature problems.

Big Creek at a Glance

1998 303(d) listed stream miles	12.25
Geomorphic characteristics	Third order stream Rosgen B channel
Salmonid spawning	Rainbow trout and hybrid trout spawning and early rearing
Cold water biota	Macroinvertebrate index score = 5.07(lower), 4.61(upper)
Impacts to riparian area	Some minor grazing

Listing History

- Big Creek was place on the State of Idaho 303(d) list in 1996 by EPA, it was retained on the 1998 list due to a lack of information.

Waterbody Assessments

- BURP
  - 1997SLEWA014 MBI 5.07, fines 19%, w/d ratio 17.3
  - 1997SLEWA015 MBI 4.61, fines 15%, w/d ratio 10.8
- NPNF
  - Sediment yield 0.7% to 2% over base.

Recommendations and Conclusions

- Big Creek was listed for sediment. However, good macroinvertebrate scores and low sediment yield overall indicated that the stream should be de-listed for sediment.

Big Mallard Creek at a Glance

1998 303(d) listed stream miles	18.77
Geomorphic characteristics	Third order stream Rosgen C Channel
Salmonid spawning	Multiple size classes of brook trout
Cold water biota	Macroinvertebrate index scores = 5.06(lower), 5.31(upper)
Impacts to riparian area	Some minor grazing and timber harvesting

Listing History

- Big Mallard Creek was place on the State of Idaho 303(d) list in 1996 by EPA, it was retained on the 1998 list due to a lack of information.

Waterbody Assessments

- BURP
  - 1997SLEWC012 MBI 5.31, fines 20%, w/d ratio 10.9
  - 1997SLEWC015 MBI 5.06, fines 19%, w/d ratio 21.8
- NPNF
  - Sediment yield 3.5% over base for CEW.
  - Temperature exceed criteria for bull trout at mouth.

Recommendations and Conclusions

- Big Mallard Creek was listed for sediment. However, good macroinvertebrate scores and low sediment yield overall indicated that the stream should be de-listed for sediment. Temperature criteria violations at mouth are probably not in spawning areas.

Little Mallard Creek at a Glance

1998 303(d) listed stream miles	8.78
Geomorphic characteristics	Second order stream Rosgen A channel
Salmonid spawning	No fish observed; migration barrier at mouth
Cold water biota	Macroinvertebrate index score = 4.25
Impacts to riparian area	Some minor mining, grazing, timber harvesting

Listing History

- Little Mallard Creek was place on the State of Idaho 303(d) list in 1996 by EPA, it was retained on the 1998 list due to a lack of information.

Waterbody Assessments

- BURP
  - 1997SLEWA017 MBI 4.25, fines 18%, w/d ratio 30.1
- NPNF
  - Sediment yield 2% over base.

Recommendations and Conclusions

- Little Mallard Creek was listed for sediment. However, good macroinvertebrate scores and low sediment yield overall indicated that the stream should be de-listed for sediment.

Jersey Creek at a Glance

1998 303(d) listed stream miles	7.65
Geomorphic characteristics	Second order stream Rosgen A Channel
Salmonid spawning	Rainbow trout, cutthroat trout, steelhead rearing
Cold water biota	Macroinvertebrate index scores = 4.93
Impacts to riparian area	Some minor mining and timber harvesting

Listing History

- Jersey Creek was place on the State of Idaho 303(d) list in 1996 by EPA, it was retained on the 1998 list due to a lack of information.

Waterbody Assessments

- BURP
  - 1997SLEWC014 MBI 4.93, fines 4%, w/d ratio 23.1
- NPNF
  - Sediment yield 3.8% over base.

Recommendations and Conclusions

- Jersey Creek was listed for sediment. However, good macroinvertebrate scores and low sediment yield overall indicated that the stream should be de-listed for sediment.

Rhett Creek at a Glance

1998 303(d) listed stream miles	8.39
Geomorphic characteristics	Second order stream Rosgen B channel
Salmonid spawning	Multiple age classes above and below migration barrier
Cold water biota	Macroinvertebrate index score = 5.13
Impacts to riparian area	Some minor mining, grazing, timber harvesting

Listing History

- Rhett Creek was place on the State of Idaho 303(d) list in 1996 by EPA, it was retained on the 1998 list due to a lack of information.

Waterbody Assessments

- BURP
  - 1997SLEWA013 MBI 5.13, fines 23%, w/d ratio 39.4
- NPNF
  - Sediment yield 0.7% over base for CEW.

Recommendations and Conclusions

- Rhett Creek was listed for sediment. However, good macroinvertebrate scores and low sediment yield overall indicated that the stream should be de-listed for sediment.

Salmon River at a Glance

1998 303(d) listed stream miles	76.90
Geomorphic characteristics	Major River
Salmonid spawning	Anadromous and resident salmonid migration
Cold water biota	Macroinvertebrate index scores = NA
Impacts to riparian area	Some minor homesteading and recreation

Listing History

- Salmon River was place on the State of Idaho 303(d) list in 1996 by EPA, it was retained on the 1998 list due to a lack of information. Listed pollutants are unknown.

Waterbody Assessments

- BURP
  - NA
- NPNF
  - Sediment yield - minimal contributions from subbasin activties.

Recommendations and Conclusions

- Salmon River was listed for unknown pollutants. However, low sediment yield overall and the lack of other documented problems within the subbasin indicated that the river should be de-listed.

Warren Creek at a Glance

1998 303(d) listed stream miles	16.15
Geomorphic characteristics	Third order stream Rosgen A-C channel
Salmonid spawning	Several salmonid species observed below migration barrier
Cold water biota	Macroinvertebrate index score = 4.99(upper), 4.93(lower)
Impacts to riparian area	Some major mining, timber harvesting

Listing History

- Warren Creek was place on the State of Idaho 303(d) list in 1996 by EPA for habitat alteration, it was retained on the 1998 list due to a lack of information.

Waterbody Assessments

- BURP
  - 1997SLEWA022 MBI 4.99, fines 5%, w/d ratio 42.3
  - 1997SLEWA023 MBI 4.93, fines 8%, w/d ratio 55.7
- PNF
  - Sediment surface fines 15% or less.

Recommendations and Conclusions

- Warren Creek was listed for habitat alteration. Good macroinvertebrate scores and low surface fine sediment indicated that the stream does not have a sediment problem. However, the stream should remain listed for habitat alteration due to extensive dredge mining.

MIDDLE SALMON RIVER-CHAMBERLAIN CREEK SUBBASIN ASSESSMENT

The middle Salmon River-Chamberlain Creek subbasin (Hydrologic Unit Code #17060207) (from here on referred to as the Salmon-Chamberlain subbasin or, on maps, Main Salmon - Chamberlain) is in north-central Idaho (Map 1−Subbasin Location). The mainstem Salmon River originates in the Sawtooth and Lemhi Valleys of central and eastern Idaho. The area under consideration includes the middle segment of the main Salmon River and its tributaries from its confluence with the Middle Fork Salmon River to, but not including, French Creek. Floating downstream and entering the subbasin from the east, the first few sub-watersheds encountered include Corn, Bear Basin, and Kitchen Creeks, and the last few watersheds before leaving the subbasin on the western edge are Wind River, Carey and Fall Creeks (Map 2−Surface Water Hydrology). The Salmon River flows through a vast wilderness (Frank Church River of No Return Wilderness and Gospel Hump Wilderness) in the Salmon River Gorge, second deepest gorge in the lower 48-contiguous states, more than one mile deep.

PHYSICAL AND BIOLOGICAL CHARACTERISTICS

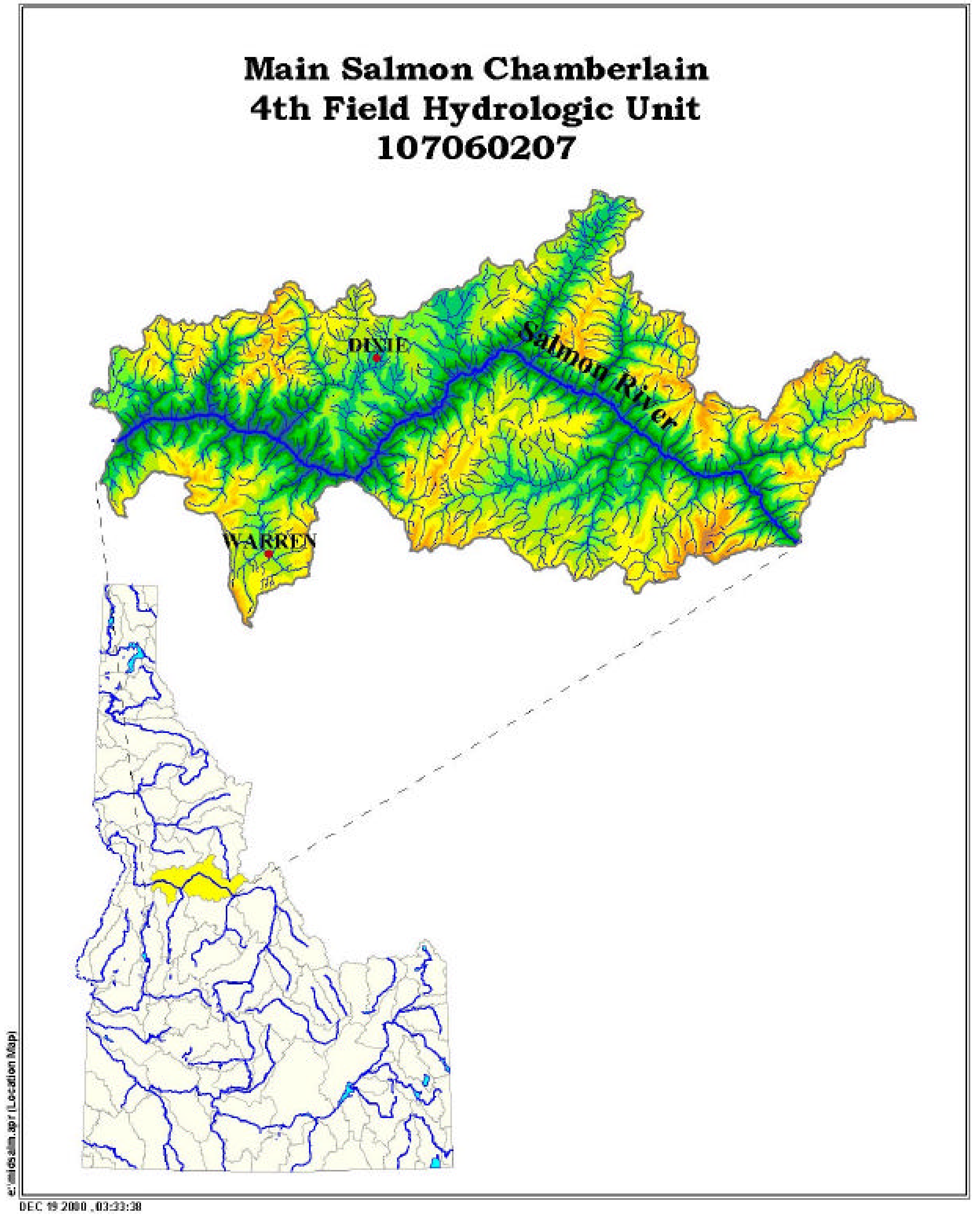
CLIMATE

Northern Idaho climate is dominated by Pacific maritime air masses and prevailing westerly winds. Precipitation at Dixie is nearly 30 inches annually, but at higher elevations can be as high as 50 to 60 inches annually (NPNF, 1999a). Mid- to high-elevation precipitation is generally high enough to support forested ecosystems. Annual precipitation at lower elevations is in the range of 15 to 25 inches (NPNF, 1999a) The subbasin is typical of many central Idaho drainages: relatively high mountains with large snowpack giving way to warmer, drier canyons at lower elevations. Temperature and precipitation normals for three climatological stations in or near the subbasin are presented in Table 1.

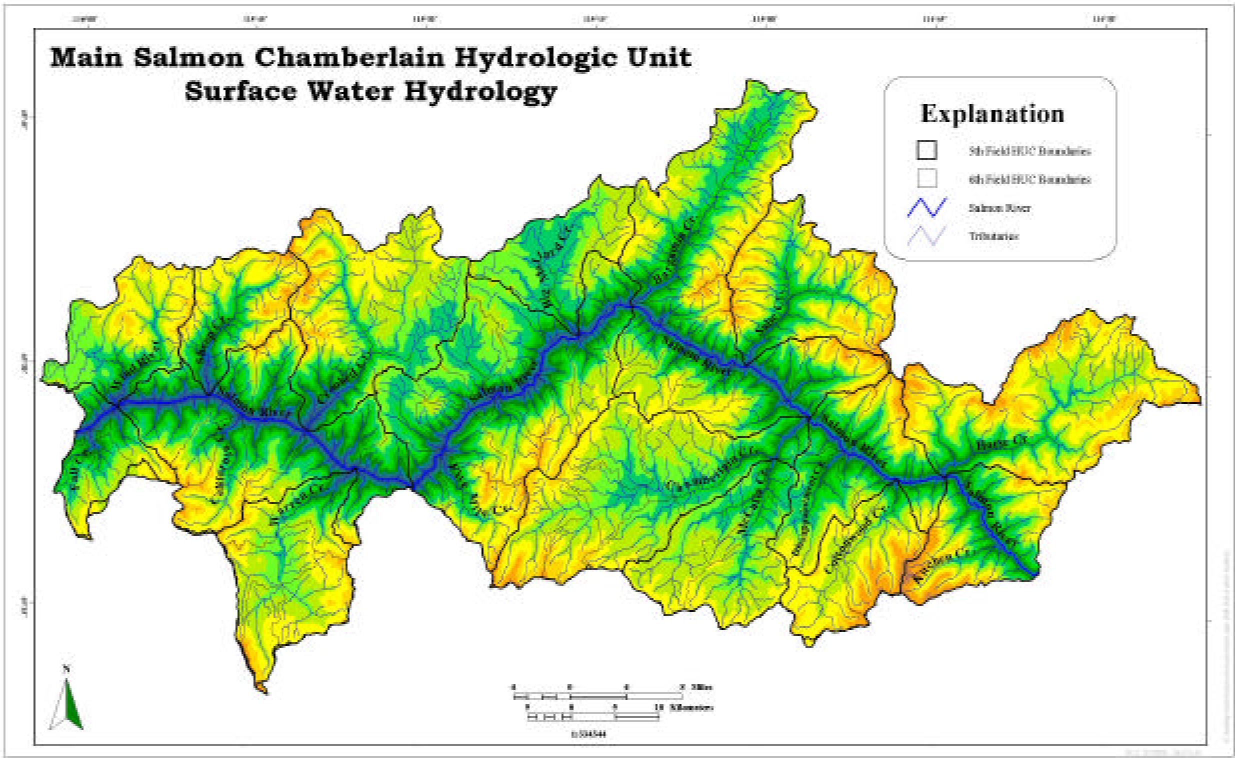
Table 1. Normals for precipitation and temperatures 1961-1990 (From: Abramovich et al., 1998).

Station Name	ID No.	Elev. (feet)	Lat.	Long.	Mean Annual Precipt. (inch.)	Total Ave. Snowfall (inch.)	Mean Annual Temp. (^{O}F)	Ave. Annual Daily Max. ^{O}F	Ave. Annual Daily Min.^{O}F
Dixie	2575	5620	45:33	115:28	29.60	206.8	35.8	50.7	20.9
Riggins	7706	1800	45:25	116:19	17.45	7.9	54.0	65.8	42.1
Warren	9560	5910	45:16	115:40	27.10	177.3	37.5	53.5	21.4

Map 1. Location Map



Map 2. Surface Water Hydrology



Elevations within the subbasin range from around 1900 feet at the mouth to over 9000 feet in the mountains at the east end of the subbasin. Climate stations at Dixie and Warren represent the mid-range in elevation. Higher elevations in the subbasin would be expected to be cooler with higher annual precipitation. The Riggins station is at a lower elevation than the subbasin; however, it reflects the drier, warmer conditions present in the canyon near the mouth of the subbasin.

HYDROLOGY

The U.S. Geological Survey (USGS) gage station for White Bird (Table 2) (Map 3XUSGS Gaging Stations) which is downstream from the subbasin and other USGS station data from tributaries in and around the subbasin (Table 3) give some indication of the flows experienced within this subbasin. The drainage area above White Bird is 13,550 square miles (mi^2) and includes most of the Salmon River basin from Stanley to White Bird. This gaging station records the accumulative flow of the Salmon River originating near Galena Summit and includes the North Fork, Middle Fork, South Fork, the Little Salmon River, Lemhi River, Pahsimeroi River and the many tributaries. With an average annual mean flow over 11,000 cubic feet per second (cfs) at White Bird, more than half this flow (6400 cfs) is added by the Salmon River basin above the Salmon-Chamberlain subbasin, the Middle Fork, and the South Fork. The remaining 5000 cfs comes from the subbasin and Panther Creek, Little Salmon River, and all the tributaries between the subbasin and White Bird. Five and ten year peak flows approximate 80,000 to 96,000 cfs (Table 4).

Table 2. Downstream Flow and Basin Runoff - Salmon River at White Bird, ID, USGS Station # 13317000. Ac-Ft = Acre-feet; CFSM = cubic feet per square mile.

Years	Average Annual Mean (cfs)	Highest Annual Mean (cfs)	Lowest Annual Mean (cfs)	Annual Runoff (Ac-Ft)	Annual Runoff (CFSM)	Annual Runoff (Inches)
1910-1998	11210	17870 (1997)	5812 (1931)	8124000	0.83	11.25

Map 3. USGS Gaging Stations

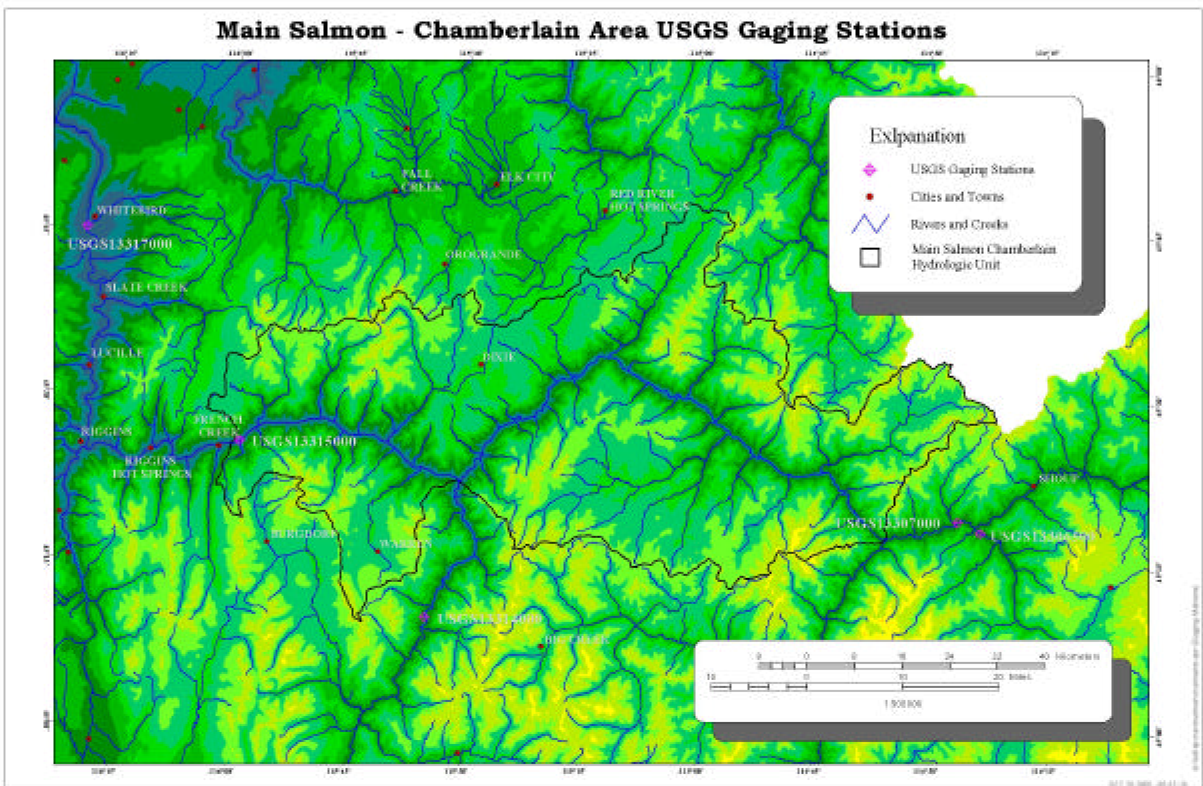


Table 3. Contributing Flows in and Around the Subbasin.

Station Name	Station #	Data Years	Average Annual (cfs)	Highest annual flow in cfs (year of occurrence)	Lowest annual flow in cfs (year of occurrence)
Salmon R. near Shoup	13307000	1944-1981	3037	4513 (1965)	1813 (1977)
MF Salmon R. at mouth	13310199	1993-1996	1753	2151 (1995)	1355 (1994)
SF Salmon near Warren	13314300	1993-1996	1645	2327 (1995)	963 (1994)
Warren Cr. Near Warren	13314500	1943-1949	48	71 (1948)	30 (1944)

Table 4. Magnitude and Frequency of Instantaneous Peak Flow.

Station Name	Station #	Period of Record	Discharge (cfs) by Frequency of Occurrence (years) and Probability of Exceedance (%)				
			2 (50%)	5 (20%)	10 (10%)	25 (4%)	50 (2%)
Panther Cr. Near Shoup	13306500	1945-1977	1,740	2,500	2,980	3,550	3,960
Salmon R. near Shoup	13307000	1945-1981	13,400	18,200	21,000	24,400	26,700
SF Salmon near Warren	13314000	1932-1948	11,600	15,100	17,300	19,900	21,700
Salmon R. near French	13315000	1945-1956	61,300	75,000	82,800	91,500	97,300
Salmon R. at White Bird	13317000	1894, 1911-1917, 1920-1997	61,300	82,900	96,000	111,000	122,000

The Salmon River canyon is steep and rocky, with an average gradient of approximately 0.23%, and the channel alternates between large pools and boulder-dominated rapids (Clearwater Basin Bull Trout Technical Advisory Team, 1998). The hydrology of tributaries tends to be dominated by snowmelt runoff from the Sawtooth and Salmon River Mountains in the south and the Clearwater and Bitterroot Mountains in the north. Snowmelt runoff generally produces high-gradient, high-energy stream systems. Gradients average 7.7% for first and second order streams.

GEOLOGY AND GEOMORPHOLOGY

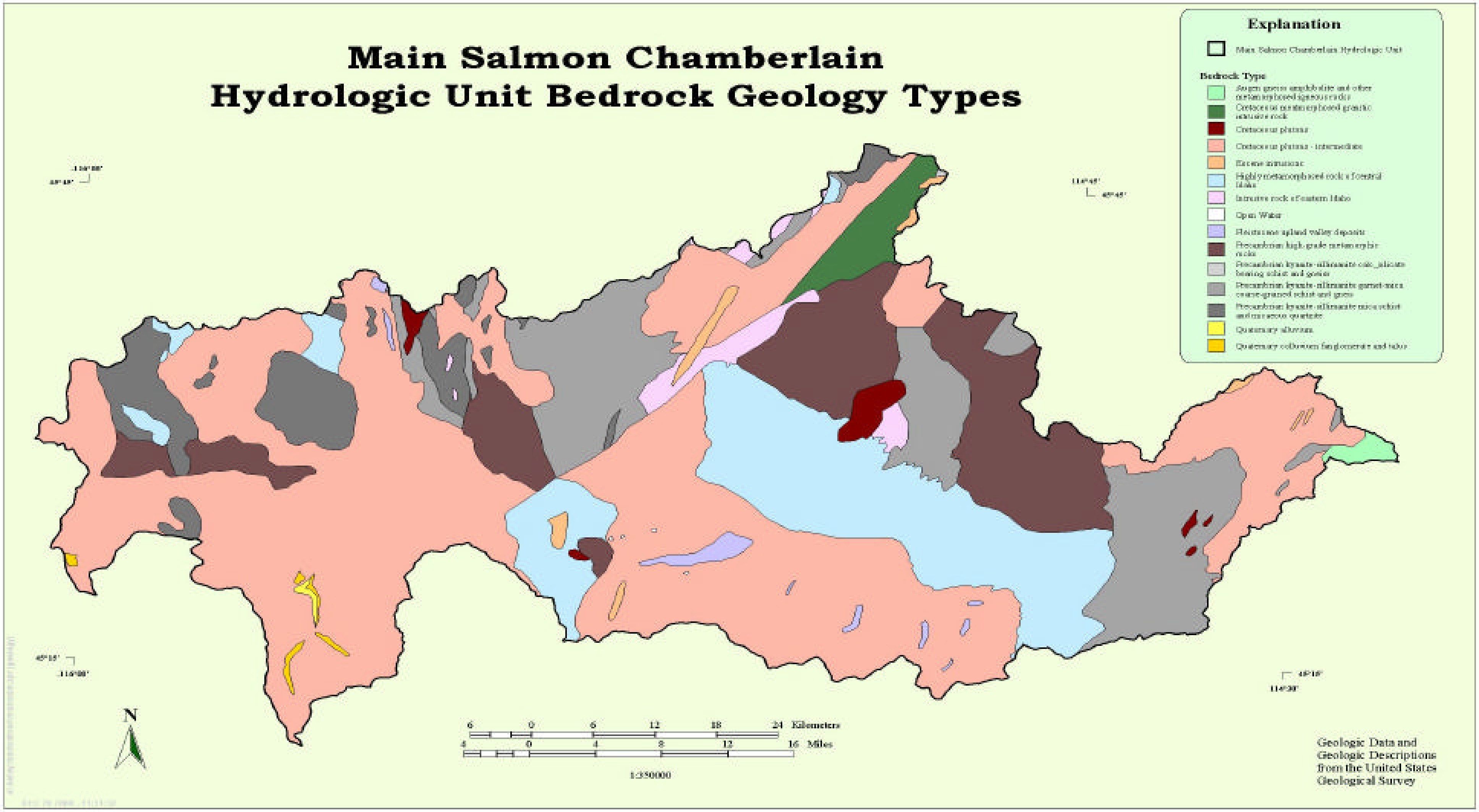
The geology of the subbasin is a combination of Idaho batholith (mostly Cretaceous aged rock; green, blue, and salmon colors on Map 4) and metamorphic Precambrian basement rocks (shades of gray and maroon colors on Map 4) that intergrade with each other throughout the area (Map 4–Bedrock Geology). The Salmon River flows through an area referred to as the Salmon River Arch, an expanse of Precambrian basement rock considered to be old continental crust that separates the northern and southern parts of the Idaho batholith (Alt and Hyndman, 1989). The Precambrian basement complex is mostly comprised of 1,500 million-year-old gneiss and schists, metamorphosed from much older rock under intense heat and pressure.

The Idaho batholith is a pale greyish granite approximately 75 million years old (Alt and Hyndman, 1989). It is made up primarily of feldspar crystals intergrown with quartz. Throughout the rock are scattered black-colored crystals, either flakes of biotite mica or needles of hornblende. Several thousand feet thick, the Idaho batholith=s sheets of granite resulted from an intrusion of magma rising up from below. As the magma encountered native rock of similar density, it spread out horizontally in the subsurface underlying large expanses of central Idaho. The Salmon River Arch is thought to be a broad anticline that warped the granite sheet upward, thus allowing it to erode and expose the underlying, older metamorphic basement rock. A few miles west of French Creek, the canyon cuts through the suture zone between the former western coastline of the continent and an old chain of volcanic islands which became the Seven Devils complex. These volcanic islands accreted onto the side of the continent at a subduction zone between colliding crustal plates. Presumably, the subduction of oceanic crust under the continent led to the melting and rising of magma to form the batholith which appeared soon after the joining of the Seven Devils complex (Hyndman, 1989). Down the Salmon River canyon towards French Creek, the pale grey granite of the batholith gives way to darker mylonite, sheared granite caused by the collision and subduction.

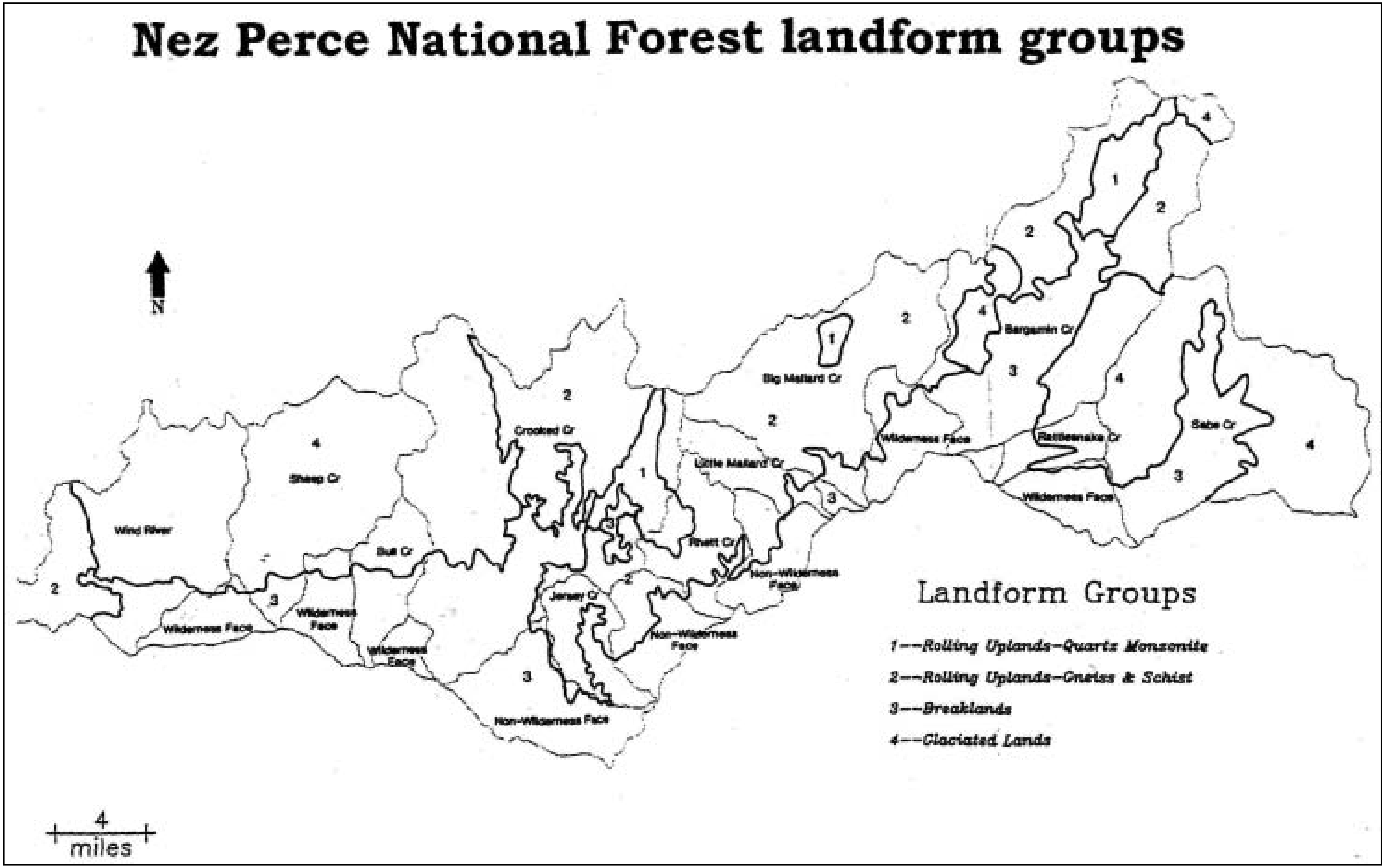
The moderately well-weathered crystalline rock is highly erodible, generating sand and gravel-sized sediment throughout most of the northern upland areas of the subbasin. Natural sediment sources in the rolling upland channel reaches are channel erosion and, to a lesser extent, surface erosion. Surface erosion is generally inhibited by a volcanic-rich soil layer that acts as a buffer in undisturbed areas. Sediment transport occurs primarily during the spring runoff and often as a result of summer precipitation events. Mass wasting is generally considered a relatively insignificant source.

On the north side of the subbasin, the Nez Perce National Forest has identified four natural stratifications within the scope of this Subbasin Assessment, which are represented by Landform Groups (Map 5–Nez Perce National Forest Landform Groups). A landform group is based upon geomorphology, geology, stream morphology, vegetation, disturbance regimes (including fire), and climate. A full description and discussion of the four landform groups including composition, structure, function, and the range of natural variability of each ecological system is provided in Biological Assessment Main Salmon River Tributaries (Northeast) Watershed Analysis Area (NPNF, 1994).

Map 4. Bedrock Geology



Map 5. Nez Perce National Forest Landform Groups



Landform Group One (LFG-1) is characterized by rolling upland hills derived from moderately well weathered granite, which is highly erodible. Under natural conditions, surface erosion occurs as a response to wildfire. Generally, the ability of riparian vegetation to recover after disturbance is limited due to low soil productivity. LFG-1 occurs in three primary areas of the subbasin: upper Crooked Creek valley bottom, including the lower reaches of Crooked Creek's numerous tributaries, a small portion of Big Mallard Creek near Jack Creek, and upper Rhett Creek. The hydrology of LFG-1 is dominated by snowmelt. The elevation ranges from 5,000 to 6,500 feet above sea level.

Landform Group Two (LFG-2) is characterized by rolling upland hills with low to moderate relief, with slopes between 20 and 50% and dendritic drainage patterns at the 1st and 2nd order. Parent materials are moderately-to well-weathered granite, gneiss, schist, and quartzite, which are highly fractured. The soils are generally capped by a volcanic ash and buffered against surface erosion unless disturbed. The hydrology is dominated by a slow and sustained snowmelt. LFG-2 occurs in the upper half of several drainages: Big Creek and Crooked Creek, Little Mallard, Big Mallard, and Jersey. The elevation ranges from 5,000 to 7,600 feet above sea level. Landform Group Three (LFG-3) is characterized by steep to very steep stream breaklands and mountain slopes along the mainstem Salmon River. Parent materials are moderately well- weathered granite, gneiss, schist, and quartzite. These surfaces are highly erodible, especially along the steepest south aspects, generating mostly sand and cobble-sized materials. Where soil occurs, they are shallow to moderately deep over the bedrock. Slopes range from 40 to 80% with parallel drainage channels. LFG-3 occurs along the mainstem Salmon River, the lower two miles of its tributaries, as well at the lower half of large drainages such as Crooked, Sabe, and Bargamin. Much of this landform is contained within the Gospel-Hump and Frank Church wilderness areas. The elevation ranges from 2,000 to 6,800 feet above sea level.

Landform Group Four (LFG-4) includes alpine glaciated lands from 6,800 to 8,900 feet in elevation. This group includes the upper reaches of the Wind River, Sheep Creek, Crooked Creek, and Sabe Creek drainages. The area is characterized by steep ice-scoured cirques and troughs and gently sloping ice scoured ridges, valley bottoms, and moraine deposits. Parent materials are poorly- to well-weathered hard crystalline rock, including granite, gneiss, schist, and quartzite, highly erodible except with enough rock to buffer movement. Soils are shallow with some deeper pockets and volcanic ash tends to be intermixed rather than layered.

TOPOGRAPHY

The hills surrounding the Salmon River canyon are softly rounded haystacks in appearance and composed of a thick mantle of soil and weathered rock. The thick soil along with sufficient precipitation allows for the near complete forested canopy. The western and southern portions of the subbasin are underlain by batholith, which erodes to granular sugar, giving the hills their soft, rounded appearance. The older metamorphic basement rock found in the lower canyon and on the north side above Sabe Creek give the river's edge its distinctly rugged appearance.

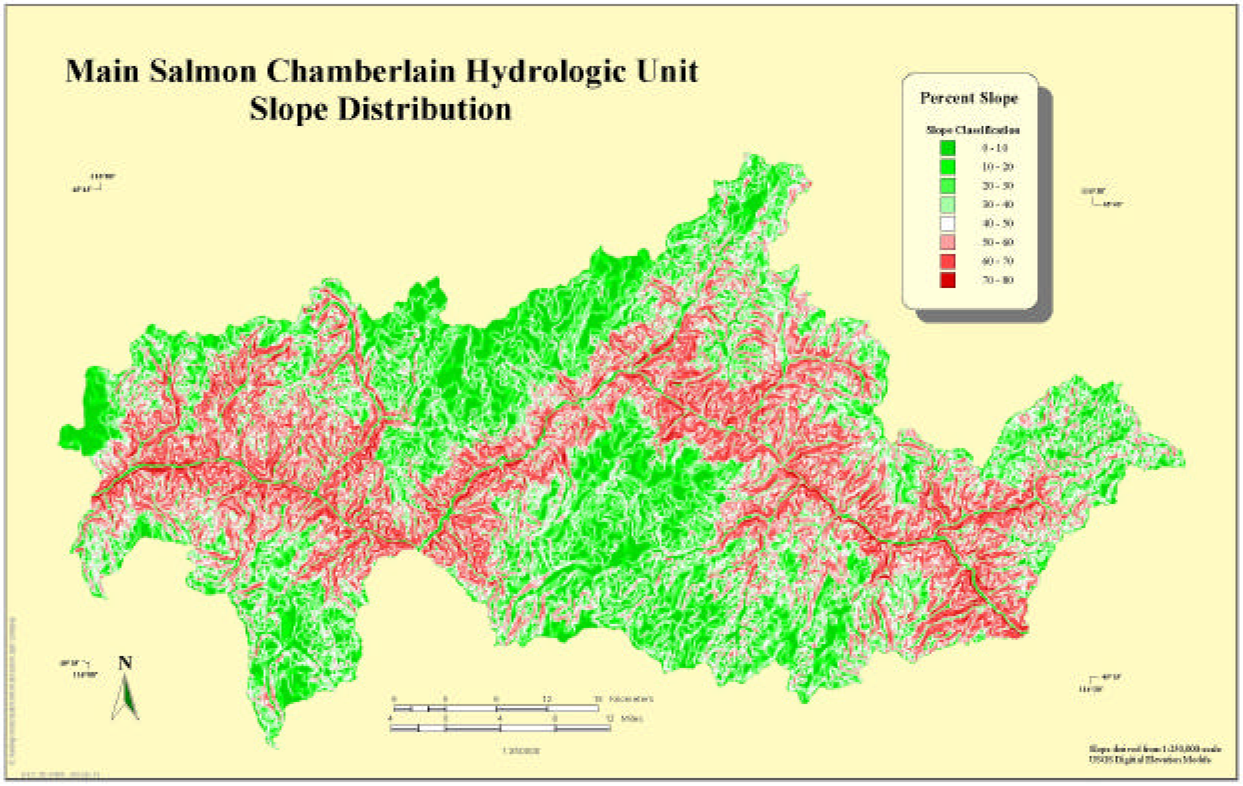
The rolling uplands vary in elevation from greater than 9000 feet at Cottonwood Butte in the southeast to 6700 feet at Black Butte on the western edge of the subbasin. Elevations in the canyon at the river=s edge vary from near 3000 feet at the eastern end of the subbasin to approximately 1900 feet at the western end. Typically, face drainages and the lower portions of major drainages are higher gradient as water runs off the rolling highlands and then plunges into the deeper canyon to join the Salmon River (Map 6−Slope Distribution). Drainages run basically north-south in the subbasin with those on the north side of the canyon draining south and the south side of the canyon draining north. North-south drainages create more east- and west-facing slopes. In general, north-facing slopes are the coolest and south-facing slopes the warmest, since they receive more direct sunlight. East- and west-facing slopes are more intermediate with west-facing slopes slightly warmer as late afternoon sun tends to cause warmer air temperatures.

VEGETATION

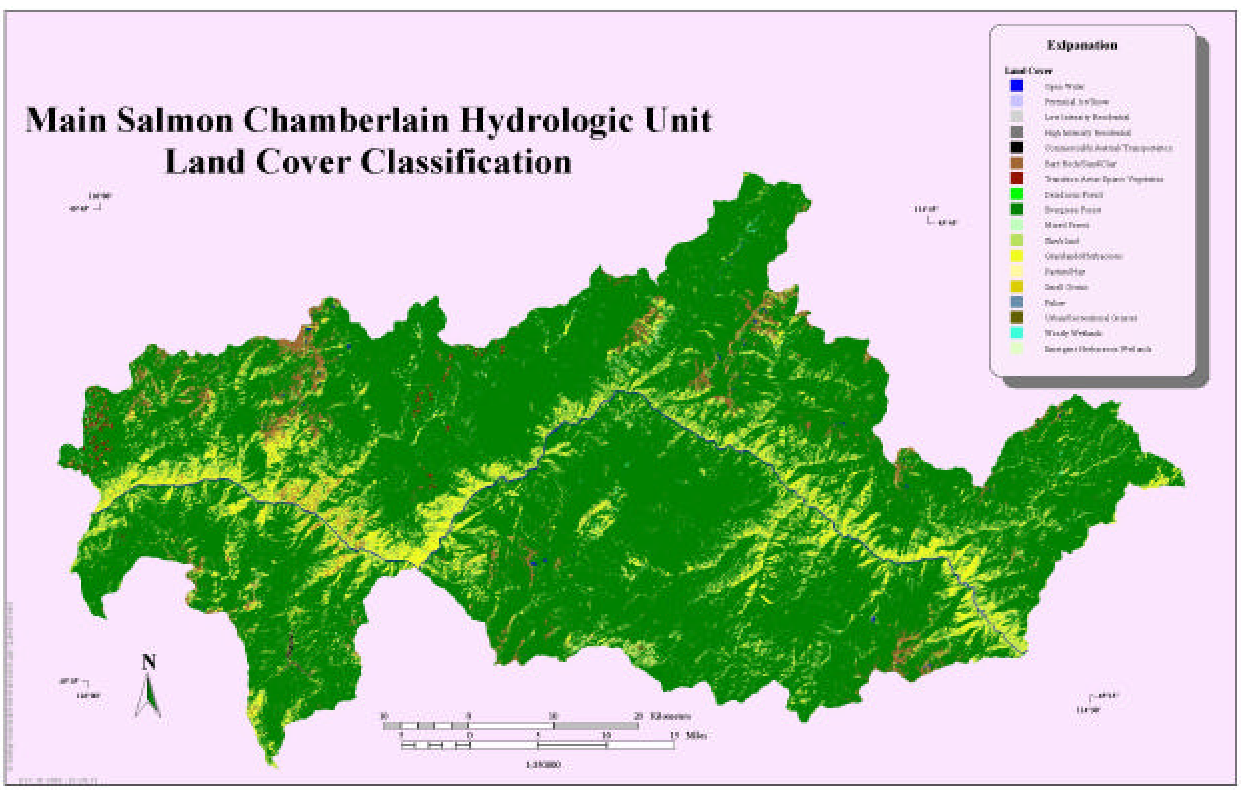
The subbasin is substantially forested, but the lower elevation canyon walls, along the Salmon River especially, are often in shrublands, sagebrush (*Artemisia sp.*) and/or mountain mahogany (*Cercocarpus sp.*) (Map 7−Land Cover Classification). The principle forest types are ponderosa pine (*Pinus ponderosa*) within drier elevations at 2,000 to 6,500 feet, especially on the south side of the Salmon River; Douglas fir (*Psuedotsuga menziesii*) on more mesic sites; mixed conifers with a predominance of grand fir (*Abies grandis*) at mid-elevations between 4,500 to 6,500 feet; and subalpine fir (*Abies lasiocarpa*) at higher elevations above 6,500 feet (Steele et al., 1981; NPNF, 1999a). In addition, a number of other conifers may be present in mixed communities or locally dominant, including western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta*), whitebark pine (*Pinus albicaulis*), western white pine (*Pinus monticola*), and Engelmann spruce (*Picea engelmannii*).

Fire cycles vary considerably between lower elevation canyon shrublands and higher elevation forests. Breaklands may have experienced short interval (10 to 20 years) cool surface fires on southern aspects before fire suppression (NPNF, 1994). Many of these smaller fires may have been started by indigenous peoples. Upland stand-replacing natural fires occur every 117 to 150 years, and 174 years or more for valley bottoms (NPNF, 1994). Forested communities at higher elevation glaciated lands experience fire every 100 to 150 years in lodgepole, 200+ years in riparian areas (NPNF, 1994). The open whitebark pine/subalpine fir communities at ridge-tops experience small infrequent fires because of discontinuous fuel distribution and cooler temperatures. Stand-replacing fires were infrequent in these ridge-top areas, with fire-free intervals ranging from 63 to 300 years (NPNF, 1994). Shrublands dominated by sagebrush/bunchgrass may experience fires every 40 to 100 years. Because of fire-suppression efforts, the number of acres burned in the last 125 years is four times less than for similar periods in pre-settlement times. The fire cycle today is considered to be a four-fold reduction in acres burned or 125 years, compared to that for pre-settlement times.

Map 6. Slope Distribution



Map 7. Land Cover Classification



The year 2000 fire season has proved to be one of the largest in recorded history. Portions of this subbasin have been burned in 2000 primarily in the Payette National Forest. The Burgdorf Junction fire burned over 64,000 acres between July 15, 2000 and September 4, 2000 (Payette National Forest, 2001). The majority of the burned area includes most of the California Creek watershed, the northern half of the Carey Creek watershed, and a portion of lower Warren Creek watershed. Tha majority of the fire area in this subbasin has been categorized as low intensity burn (unburned to <50% scorched canopy) (BAER Team, 2000). Smaller areas of moderate intensity burn exist in portions of California Creek watershed, especially near the headwaters. Effects of wildfires on listed watersheds is relatively minor due to low intensity burns in a small portion (11%) of Warren Creek drainage (Zuniga, 2001). Moderate intensity burns occurred on 2% of the Warren Creek watershed. Planned restoration activities in the Warren Creek drainage include several miles of trail relocation and probably some road maintenance (Zuniga, 2001). Little fire rehabilitation is necessary in Warren Creek because the area burned is primarily roadless and the fire intensity was low (Zuniga, 2001).

Because the subbasin is predominantly in designated wilderness (61% of total area), very little timber harvesting has occurred. The Nez Perce National Forest reports some 3,000 acres (<1% of total area, 2% of non-wilderness national forest area) have been harvested, primarily by clear-cut logging from the area on the north side of the Salmon River between Wind River and Sabe Creek (NPNF, 1994). Between 1970 and 1998, 14,000 acres per year (less than 1 percent) were burned on average, mostly in wilderness (USFS, 1999).

FISH

The free-flowing nature of the main Salmon River and the abundance of wilderness area means this subbasin is likely to contain some of the better conditions for native fisheries in the state. Many streams provide habitat for spawning and early rearing for anadromous fish. Native fish reported to inhabit the subbasin include: sockeye salmon (*Oncorhynchus nerka*), northern pikeminnow (*Ptychocheilus oregonensis*), mottled sculpin (*Cottus bairdi*), shorthead sculpin (*C. confusus*), torrent sculpin (*C. rhotheus*), speckled dace (*Rhinichthys osculus*), longnose dace (*R. cataractae*), leopard dace (*R. falcatus*), Pacific lamprey (*Entosphenus tridentatus*), mountain whitefish (*Prosopium williamsoni*), westslope cutthroat trout (*O. clarki lewisi*), redband trout and steelhead (*O. mykiss*), fall, spring-summer chinook salmon (*O. tshawytscha*), bull trout (*Salvelinus confluentus*), redside shiner (*Richardsonius balteatus*), bridgelip sucker (*Catostomus columbianus*), largescale sucker (*C. macrocheilus*), mountain sucker (*C. platyrhynchus*), and white sturgeon (*Acipenser transmontanus*) (Lee et al., 1980; Simpson and Wallace, 1980; Clearwater Basin Bull Trout Technical Advisory Team, 1998).

Non-native and hatchery fish have been introduced into various areas within the subbasin. Most alpine lakes originally did not contain native fish. Introduced species include brook trout (*S. fontinalis*), Yellowstone cutthroat trout (*O. clarki bouvieri*), and rainbow trout (*O. mykiss*) (Payette National Forest, 1999).

The Main Salmon River Bull Trout Problem Assessment (Clearwater Basin Bull Trout Technical Advisory Team, 1998) has identified seventeen bull trout sub-watersheds in this subbasin. Most were described as subadult and adult rearing areas, although five watersheds (Bargamin, Sabe, Chamberlain, Warren, and Fall Creeks) were identified as spawning and early adult rearing areas. Native fisheries in the Bargamin and Sabe watersheds appear to be the most productive. Bull trout spawning is suspected in the lower reaches of Crooked Creek (Clearwater Basin Bull Trout Technical Advisory Team, 1998). Bull trout spawning is suspected in Sheep Creek and Wind River. Carey Creek apparently has no bull trout, and a possible migration barrier to other species at mile 5.5. No information is available for Harrington Creek. The main Salmon provides subadult and adult rearing habitat for bull trout as well as connectivity for the movement of fish throughout the subbasin.

Designated critical habitat for chinook salmon extends from the mouth of the Salmon River through this subbasin, and includes many streams accessible to salmon (Clearwater Basin Bull Trout Technical Advisory Team, 1998). According to the Bull Trout Problem Assessment, chinook salmon spawning or juvenile rearing have been detected in Bargamin, lower Crooked, Sheep, Rhett, Little Mallard and Big Mallard Creeks, and lower Wind River watersheds. Steelhead have been found in Sabe, Bargamin, Big Mallard, lower Sheep, and lower Wind watersheds. Additionally, Chamberlain Creek and West Fork Chamberlain Creek have significant spawning and rearing for chinook salmon and steelhead (A. VanVooren, pers. comm., 2000). Cutthroat trout are documented in Sabe and Big Mallard watersheds (Clearwater Basin Bull Trout Technical Advisory Team, 1998). Fall chinook salmon have been reported in the Salmon River just downstream of Mackey Bar. Redds were observed that were probably made by fall chinook salmon (A. Van Vooren, pers. comm., 2000).

Crooked Creek has a possible migration barrier 3/4 miles below Big Creek, with steelhead and bull trout below the barrier and resident and hatchery rainbows, cutthroats and possibly some rainbow/cutthroat hybrids above the barrier (NPNF, 1999a). The 10,000 acre Jersey Creek drainage has steelhead/rainbow juveniles and no barriers, but no bull or cutthroat trout were observed (NPNF, 1999a). Crooked Creek is considered important in terms of fish production due to both its size and accessibility to the mainstem Salmon River (USFS, 1999). The sub-watershed supports spring/summer chinock salmon, rainbow/steelhead trout, westslope cutthroat trout, and bull trout.

Rhett Creek supports juvenile spring/summer chinook rearing at the mouth (NPNF, 1994). Rhett Creek has a barrier at 0.7 mile from the mouth. Steelhead spawning occurred in the lower half-mile and cutthroat and bull trout were present when sampled by the Forest Service; no chinook were observed however (NPNF, 1999a). Additionally, bull trout sub-adult and adult rearing may occur.

Little Mallard Creek has a barrier ½mile from the mouth according to the Forest Service. Steelhead/rainbow and bull trout have been observed, but not chinook or cutthroat trout (NPNF, 1999a). However, the creek supports juvenile spring/summer chinook rearing at the mouth. Subadult and adult bull trout are located below the falls in the lower reach near the confluence (Clearwater Basin Bull Trout Technical Advisory Team, 1998). A fish population does not exist above the falls. It is not clear why, but perhaps fish were not able to migrate into the stream prior to the formation of the barrier, nor have there been any introductions or those successfully reproducing. Various salmonids are also found in the Wind River and Meadow Creek.

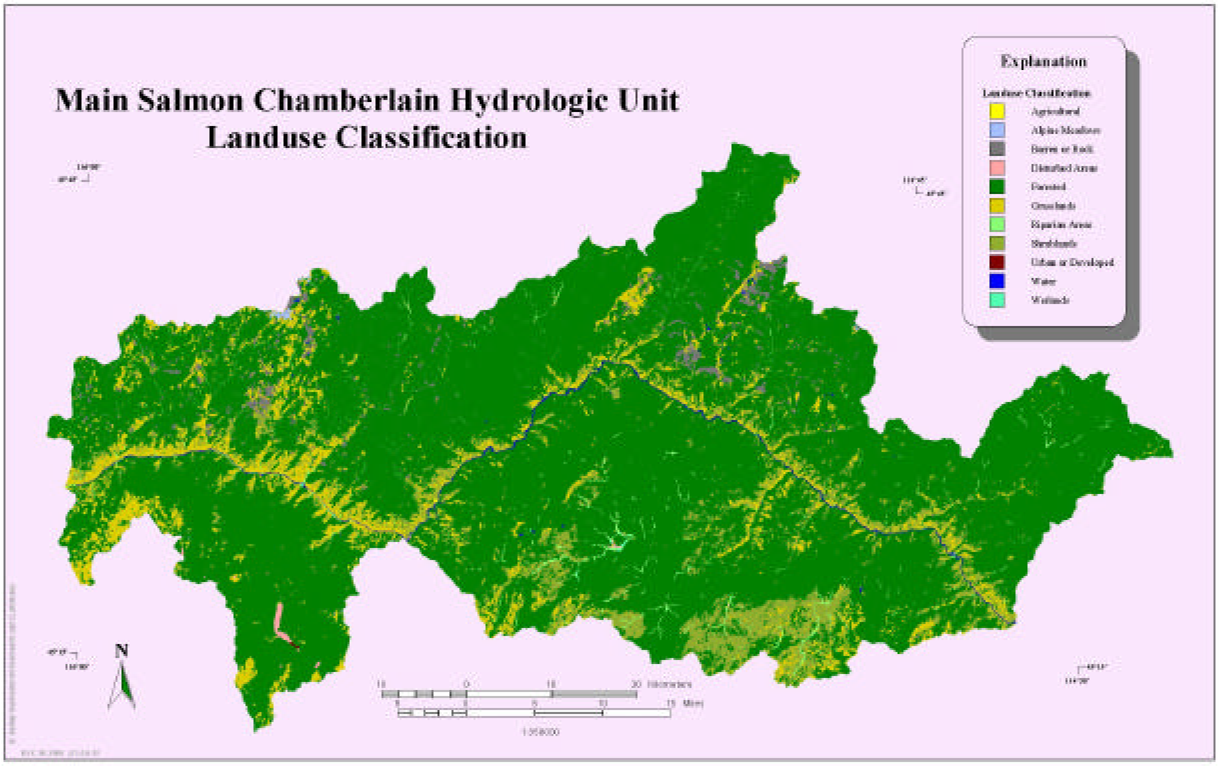
LAND OWNERSHIP AND LAND USE

The subbasin is considered almost entirely forested land use (Map 8–Landuse Classification). Many watersheds experienced mining in the past, with some mining activities still in existence today. In particular, larger mining areas include the Marshall Mountain area, Warren Creek, and the vicinity of Dixie. Commercial logging is not planned for the foreseeable future in the Nez Perce National Forest between the two wilderness areas in the vicinity of Dixie (Cove-Mallard) (Bernhardt, 2001). Timber harvest has occurred in recent times (1990's) on about 3,000 acres of the Cove-Mallard area (NPNF, 1994). Historically, much of this subbasin has been used for grazing. There is a 5,000 acre area in the upper Chamberlain fifth field HUC identified as rangeland on the land use map. This is probably a large meadow referred to as the Meadow of Doubt. This meadow is within the Frank ChurchXRiver of No Return Wilderness.

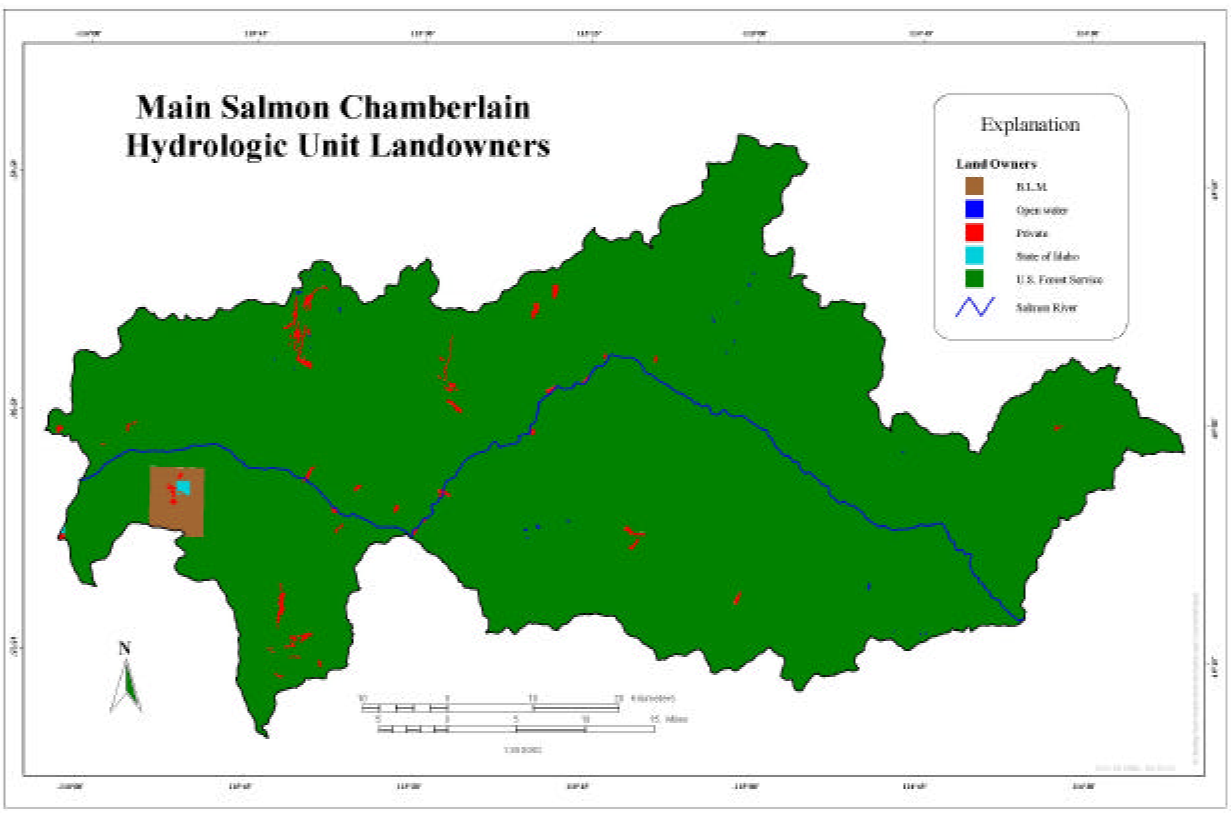
A large portion of these Forests are managed as wilderness. The Frank ChurchXRiver of No Return Wilderness flanks both sides of the Salmon River from Corn Creek to the vicinity of Mackay Bar (Map 9–Landownership). At Crooked Creek, the Gospel Hump Wilderness begins on the north side of the river; the south side continues to be the Frank Church Wilderness (Map 10–Wilderness Protection Areas). Of the 2.3 million acres in the Frank Church Wilderness, 105,000 acres are in the Nez Perce National Forest, all in this subbasin. Gospel Hump Wilderness is 200,464 acres in size and mostly in this subbasin. Wilderness boundaries end where the Wind River enters the Salmon River. The remaining stretch of the Salmon River from the Wind River to the mouth of the subbasin near French Creek is primarily National Forest outside of wilderness boundaries. The Warren Creek and Carey Creek drainages on the southwest end of the subbasin are primarily outside of wilderness, as is Corn Creek, Bear Basin Creek and the top end of Horse Creek on the east end of the subbasin.

The subbasin is almost entirely federal land (98%), mostly in the Nez Perce and Payette National Forests. The north side of the Salmon River is in the Nez Perce and Bitterroot National Forests and the south side in the Payette and Salmon-Challis National Forests. Forest boundaries split the northern half of the subbasin at Sabe Creek with the west side in the Nez Perce and the east side in the Bitterroot National Forest. The Payette and Salmon National Forests' common boundary occurs at the eastern edge of the Cottonwood Creek drainage near the eastern end of the subbasin. There are a number of small private holdings within the subbasin, most less than 500 acres in size. Many of these holdings have, and continue to be, used for mining activities. The Bureau of Land Management (BLM) has an 11,000 acre area that contains the Marshall Mountain mining area. The State of Idaho also owns a section within this BLM area.

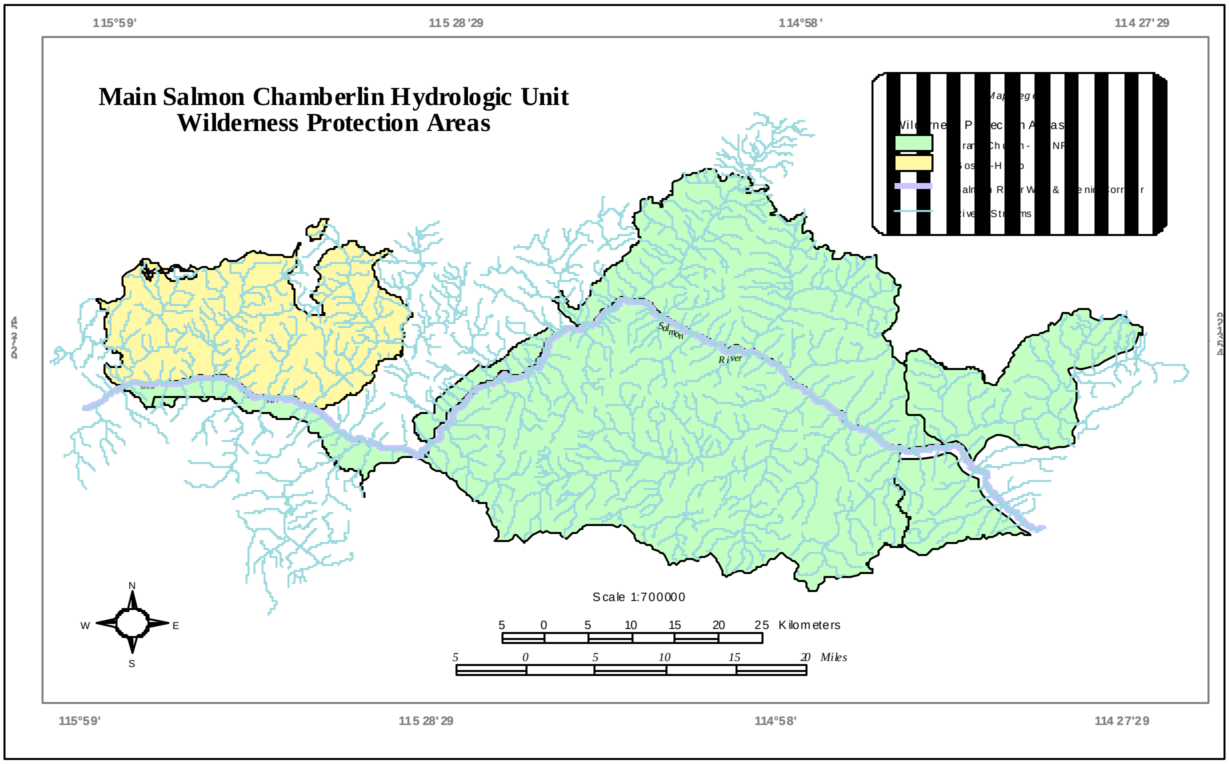
Map 8. Land Use Classification



Map 9. Land Ownership



Map 10. Wilderness Protection Area



Most of the subbasin is within Idaho County, county seat Grangeville. Population of the county is currently around 15,000, 77% of which is rural (Idaho Dept. of Commerce, 1999). A small portion of the east end of the subbasin, the Horse Creek sub-watershed and half of Kitchen Creek sub-watershed, is in Lemhi County. The extreme southern tip of the Warren Creek sub-watershed extends into Valley County. There are no incorporated cities within the subbasin. Riggins and Whitebird are the closest incorporated cities outside of the subbasin. Place names in the vicinity which may have permanent inhabitants include Warren, Burgdorf, Dixie, and Orogrande. The 1990 Census indicated that Dixie had 10 residents, and Warren had 35. Elk City and Orogrande, north of Dixie and outside of the subbasin, had populations of 450 and 10, respectively, in 1990. Most jobs are related to timber, mining, livestock grazing, recreation, or government agencies.

The Salmon River is a major recreational destination. The Salmon River has a 66-mile corridor designated as a Wild and Scenic River including most of the section flowing through the subbasin. Wild and Scenic River status includes a quarter-mile corridor on either side of the river from the western edge of the subbasin to Cherry Creek. This free flowing river provides extraordinary whitewater rafting opportunities. Thousands of people float the river annually (National Park Service, 1999). Additionally, many people enjoy the canyon for hiking, horse packing, and jet boating. Forest service permits administered by the Nez Perce and Salmon-Challis National Forests are required during the period from June 20 to September 7, for both float boats and jet boats on the wild section of the river through the subbasin. All wastes, including human excrement, must be carried out by floaters.

SUB-WATERSHED DESCRIPTIONS

Many of the descriptions of activities, disturbances, and associated water quality effects found in this section are informational or anecdotal descriptions, and should not be interpreted as verified water quality standards violations or beneficial use impairments.

The subbasin can be divided into 18 sub-watersheds or 5th field hydrologic units (Map 2). On the north side of the Salmon River are the Wind River (includes Meadow Creek), Sheep Creek, Crooked Creek (includes Big Creek), Big Mallard Creek, face drainages (includes Jersey, Rhett, Little Mallard) Bargamin Creek, Sabe Creek, and [1]Horse Creek sub-watersheds. A summary of most north-side watersheds is provided in Table 5. On the south side of the river are Carey Creek (includes Fall Creek), Warren Creek, [1]Upper Chamberlain Creek, [1]Lower Chamberlain Creek, and [1]Cottonwood Creek sub-watersheds. Straddling both sides of the Salmon River are Bull Creek (includes California Creek), Rabbit Creek, face drainages (includes Fivemile, Lemhi, Trout, and Richardson Creeks), [1]Dillinger Creek (includes Harrington Creek), [1]Disappointment Creek, and [1]Kitchen Creek (includes Corn Creek) sub-watersheds.

These sub-watersheds vary in size from 84,483 acres (Crooked Creek) to approximately 6,000 acres for some of the face drainages (NPNF, 1994, see Table 5). Many of the sub-watersheds have low road densities (<1 mi/mi^2), low disturbances (<5% of area), and very little private land. Natural sediment yields, as predicted by NEZSED, vary from 44.6 tons/square mile/yr for Bull Creek, one of the smaller sub-watersheds, to 10.4 tons/square mile/yr for the Big Mallard sub-watershed (Paradiso, 2000). Natural sediment yield is generally around 40 to 60 pounds per acre per year. Smaller face drainages may produce up to 140 pounds per acre per year. The assumptions used in NEZSED modeling are many and great, and there is a great deal of uncertainty associated with the figures. Interpretation should be cautious and the results treated as crude estimations at best (NPNF, 1994).

Tributaries to the Salmon River tend to be mountainous, high gradient, high energy streams dominated by snowmelt runoff. These streams tend to be in V-shaped valleys, of stream type Rosgen (1994) A2 - A3 or B2 - B4 (NPNF, 1999a), and with low sinuosity (Table 6). Gradients in Table 6 vary from as high as 12% in first order streams to as low as 1 to 2% at third order streams.

The steep breakland channel reaches are separated from the rest of the watershed by a series of steep cascading falls which serve as barriers to anadromous and fluvial fish migration up-gradient. The steep A-type channels in the breaklands are high energy and capable of transporting large sediment loads.

[1]Note: No information was obtained on these sub-watersheds east of Sabe and Dillinger Creeks. Most of these drainages are entirely in wilderness and have not received the attention the western half of the subbasin has received.

They are confined in V-shaped or narrow canyon bottoms. Due to the high energy nature of the channels, bank stability of these channel reaches rely on substrate size of bed and bank material and riparian vegetation. Intense storm events will scour bed and bank materials, transporting them downstream to the Salmon River.

Table 5. North-side Watershed Characteristics (NPNF, 1994; NPNF, 1999a; Paradiso, 2000).

Sub-watershed Name	Acres (sq.mi.)	Acres Disturbed (% of total)	Natural Sediment Yield (tons/sq.mi./yr)	Sediment Yield per Acre (tons/acre/yr)	Road Density (mi/mi^2)	Wilderness (%)	Private (%)
Wind River	41,347 (64.6)	1,825 (4%)	17.9	0.03	0.75	68	1
Sheep Creek	32,974 (51.5)	7 (<1%)	35.5	0.05	0.07	93	1.7
Crooked Cr.	84,483 (132)	1,282 (2%)	19.6	0.03	0.77	54	2
Big Mallard	36,530 (57)	1,416 (4%)	10.4	0.02	0.27	4	1
Little Mallard	8,215 (12.8)	No data	14.4	0.02	1.0	0	1.5
Jersey Creek	10,001 (15.6)	No data	21.7	0.03	1.14	12	<1
Rhett Creek	12,348 (19.3)	No data	13.5	0.02	1.5	7	3
Bargamin Cr.	69,989 (109.3)	45 (<1%)	15.1	0.02	0.18	72	0
Sabe Creek	53,218 (83.1)	7 (<1%)	21.8	0.03	0.15	99	0
Bull Creek	9,774 (15.3)	No data	44.6	0.07	0	100	0
Rattlesnake	6,013 (9.4)	No data	31.4	0.05	0	100	0
Face (non-wilderness)	39,493 (61.7)	No data	No data	No data	0.32	18	<1
Face (wilderness)	30,452 (47.6)	No data	No data	No data	0	100	0
Other Tributaries*	NA	No data	No data	No data	No data	No data	<1

* on the northwest side of the subbasin, includes Face drainages.

Table 6. Stream Types from Beneficial Use Reconnaissance Project Sites in Subbasin.

Creeks	Stream Order	Gradient (%)	Rosgen Type	Valley Type	Sinuosity
Rhett	2	4	B	V-shaped	low
Big (lower)	3	3	B	V-shaped	low
Big (upper)	2	4	B	Flat Bottom	moderate
Eutopia	2	6	A	V-shaped	low
Little Mallard	2	8	A	V-shaped	low
McGuire	2	4	B	V-shaped	low
Warren (U)	4	2.5	B	V-shaped	low
Warren (L)	4	2	C	V-shaped	low
Crooked (U)	3	4.5	B	Flat Bottom	moderate
Crooked (L)	3	3	B	V-shaped	moderate
Big Mallard (U)	3	2	C	Flat Bottom	high
Big Mallard (L)	3	1.5	C	V-shaped	moderate
Noble	2	8	A	V-shaped	moderate
Jersey	2	8	A	V-shaped	low
Corn	2	11	A	V-shaped	moderate
Bear Basin	2	12.5	A	V-shaped	moderate
Cramer	1	12	A	V-shaped	moderate

The channel morphology of low gradient channel reaches of Big Creek, Crooked Creek, and Big Mallard Creek is characterized by slow, incremental changes. Much of the eroded sediment is stored in the lower gradient meadow and shrub-dominated reaches. The first and second order stream reaches in forested portions of the watershed are Rosgen (1994) channel types A5 and B5, and E4 in meadow and shrub complexes. Third through fifth order streams are channel types B3 and B4 in forested portions and C3, C4, and E4 in meadow complexes. The headwater stream segments tend to transport sediment through the steeper reaches where erosion is common.

Riparian areas are typically narrow, constrained by the presence of steep mountainous terrain in the vicinity of the canyon. Farther up-gradient where hills become more rolling, riparian areas can be more broad. Some meadow-like areas exist periodically at low-gradient, mid-elevation locations. Riparian vegetation is typically dominated by spruce, fir, alder, mountain maple, thimbleberry, and a number of herbaceous plants. At lower elevations along the Salmon River, and in alpine and subalpine meadows, willow and/or herbaceous plants may dominate.

The following sections of this subbasin assessment are descriptions in alphabetical order of fourteen watersheds with some percentage of non-wilderness designation. Much of the material is summarized from the 1994 Biological Assessment: Main Salmon River Tributaries (Northeast), by the Nez Perce National Forest (NPNF, 1994), or as otherwise cited. Mean annual and mean monthly flows reported in these sections are estimates based on regional equations and reference stream gages.

BARGAMIN CREEK

Seventy-two percent (72%) of the Bargamin sub-watershed is in wilderness. The upper one third of the drainage is outside of wilderness, but managed by the Forest Service. There is no private land in the sub-watershed. Bargamin Creek originates near Three Prong Mountain at an elevation of 8,000 feet and is about 22.5 miles long. The estimated average annual discharge is 142 cfs with an estimated mean monthly flow ranging from 37 cfs to 526 cfs. The sub-watershed has almost equal proportions in all four Landform Groups. Since 1960, about 26% of the sub-watershed has been burned, only a small percentage of which received high intensity, stand-replacing fire. The sub-watershed has experienced very little development. No timber harvests or mining activity are known to have occurred. There are two vacant grazing allotments. The lower end of the drainage was heavily grazed between 1900 and 1940 before there was any management of such activities. The same areas were grazed as part of the Salmon River Breaks Allotment from 1950 to 1970. In 1971, the number of animals was reduced. General statements concerning vegetation indicated overutilization at that time. There are approximately 21 miles of road in the upper third of the drainage used for recreational purposes (NPNF, 1994).

BIG CREEK (1998 303(d) Listed for Sediment)

In lower gradient sections of Big Creek the dominant substrate is small cobbles. As gradient increases the substrate changes to large cobbles and boulders. There are localized impacts from grazing, especially in the Big Creek meadows, including bank sloughing, loss of cover, sedimentation, and soil compaction. These impacts are considered minor with little contribution to the overall Crooked Creek watershed condition (NPNF, 1994).

BIG MALLARD CREEK (1998 303(d) Listed for Sediment)

Big Mallard Creek originates near Boston Mountain at 7,600 feet elevation, and is about 15 miles long. Estimated mean annual discharge is 74 cfs with estimated mean monthly flows ranging from 14.5 cfs in September to 300 cfs in May. The majority (91%) of the sub-watershed is in LFG-2. The bottom 4% of the sub-watershed is in wilderness. Most of the sub-watershed is undeveloped; however, it has past and present timber harvesting, and past grazing impacts, including non-native vegetation introductions (Clearwater Basin Bull Trout Technical Advisory Team, 1998). There are 507 acres (1%) of private land used primarily for grazing and subsistence farming in the past. Some of it is presently subdivided and developed as recreational homes.

Timber harvest occurred within the lower Big Mallard watershed from 1965 to 1994. According to the USFS (1999), 132 acres were clearcut during 1965-67, 468 acres were harvested in 1985-88. The Grouse and Noble timber sales have been completed. The Grouse timber sale removed timber from 234 acres from 1992 to 1994. The Noble timber sale included 513 acres and was awarded in 1991. The roads for the Jack timber sales are completed and considered ongoing with planned harvest of 381 acres. There are 33 miles of road in the sub-watershed with an overall road density of 0.58 miles per square mile used for accessing timber harvests and for recreation. Two-thirds of these roads have been constructed or reconstructed since 1992.

According to the USFS (1999), the subwatershed has sustained a variety of impacts, including road construction on the watershed's naturally high erosive geology, resulting in high levels of deposited sediment.

There are two active grazing allotments, which have been in use since the 1940s. Some damage to streambanks has been documented. There is one vacant allotment in the Salmon River breaks area. There is very little evidence of mining in the sub-watershed (NPNF, 1994).

The lower three miles of Big Mallard Creek are separated from the rest of the watershed by Mallard Falls, a 1/4 mile series of very steep cascades, which prevent fish migration (NPNF, 1994). This lower section consists of steep A-type channel whereas the remaining portions of the creek are B- and C-type channels. Big Mallard Creek below the falls is a steep, high energy stream, highly entrenched, and with gradients exceeding 8% and as high as 30-40%. The dominant substrate here is boulders and large rubble. Habitat types include plunge pools, cascade riffles, and pocket water, and very few depositional areas. Above the falls, Big Mallard Creek and its tributaries are generally less than 4% gradient. These channels are sinuous and highly depositional with the dominant substrate being sand and gravels. Percent fines are generally greater than the natural levels found in Bargamin Creek (Table 7). Rooted aquatic macrophytes are common, especially in Noble, Jack, middle Big Mallard, and upper Big Mallard Creeks. Habitat types include shallow runs, riffles, and lateral scour pools. Cobble embeddedness above the falls ranges from 40 to 80%, and pebble counts indicate the average substrate size to be medium to large gravels. Jack Creek has been identified as a source of suspended sediment from grazing, timber, and road activities (Table 7).

BULL CREEK & CALIFORNIA CREEK

Bull Creek is a third order, high energy stream that enters the Salmon River from the north, and is entirely within the Gospel Hump Wilderness. Estimated mean annual discharge is 21.5 cfs and estimated mean monthly flows range from 5.6 cfs in January to 79.5 cfs in June. The entire drainage has been burned at least once since 1960, and reburns have occurred in some areas including in 2000. The drainage is largely shrub and herbaceous species dominated, especially since heavy grass reseeding occurred after a 1973 fire. No timber or mining activity has been recorded for the sub-watershed, and grazing has ceased since 1987 (NPNF, 1994).

California Creek is a 12 mile long high energy system on the south side of the Salmon River. The lower two miles of the stream are in wilderness. California Creek originates near War Eagle Lookout at an elevation of about 8,000 feet. This drainage (15,209 acres) is rugged, mountainous terrain and is somewhat remote. Road densities are less than one mile per square mile and primarily associated with mining claims. One mine site in particular has un-vegetated disturbed areas and a small perennial stream in need of some rehabilitation to prevent sediment movement during storm events. Little other human disturbance has taken place in the watershed. A tributary to California Creek extends into BLM and State land in the vicinity of the Marshall Mountain mining area. No information was obtained on any effects to the stream from these activities (PNF, 1999).

Table 7. Percent Fines (<6mm) for All Reaches of Fixed Transects (NPNF, 1999b).

Site #	Site Name	1995	1996	1997	1998
1	Little Mallard Cr. (below Noble timber sale)	34	35	17	22
2	Grouse Cr.	41	49	40	32
3	Jack Cr.	80	74	75	77
4a	Big Mallard Cr. (below Grouse Cr.)	20	19	19	21
4b	Big Mallard Cr. (above Jack Cr.)	Reach #1 Reach #2	26 34	26 36	25 27
5	Big Mallard Cr. (above Slide Cr.)	48	35	38	37
6	SF Big Mallard Cr.	43	41	24	46
7	Bargamin Cr.	26	20	17	21

CAREY CREEK

The Carey Creek sub-watershed is located on the south side of the Salmon River at the very western edge of the subbasin. The sub-watershed includes Carey Creek and Fall Creek. Fall Creek appears to have the potential to be affected by the Marshall Mountain mining area; however, no information has been obtained for this sub-watershed.

CROOKED CREEK (1998 303(d) Listed for Sediment)

Fifty-four percent of the Crooked Creek watershed is in the Gospel-Hump Wilderness, while 2% is in private ownership. Estimated mean annual discharge is about 167 cfs with estimated mean monthly flows ranging from 44 cfs in January to 619 cfs in June. Upper reaches outside of the wilderness are low gradient (<4%) and lower wilderness reaches are higher gradient (5-15%). Watershed impacts are associated with the 1992 Porcupine Fire in the wilderness portion of the sub-watersheds. The fire resulted in 20 percent of the watershed being burned at moderate to high intensity (USFS, 1999). Post-fire monitoring has estimated low to moderate rates of surface erosion into Crooked Creek from the burned areas. Since this time, numerous debris torrents and other mass movement events have been documented.

High sediment delivery and deposition exists in the upper reaches, but not in the lower reaches. This has generally been attributed to the fact that the periphery of Crooked Creek has been developed in the upper watershed and minimally developed in the lower watershed (Clearwater Basin Bull Trout Technical Advisory Team, 1998). The town of Dixie and private recreational residences border the creek. The creek was dredge mined in the past. Past mining activities and homesite development, corrals, and crossings continue to affect the stream. Since 1960, 19% of the sub-watershed has been affected by fire. There are 101 miles of road in the sub-watershed, some of which are surfaced. The entire length of Crooked Creek outside of the wilderness is paralleled by road. Timber harvesting has occurred on 782 acres in two separate events in 1976 and 1988. There are four vacant grazing allotments established as early as 1921.

Localized bank damage has been documented along Big Creek and its upper tributaries. Three allotments have been closed in the 1960s and 1970s, and one allotment is still active in the lower part of the sub-watershed associated with the Shepp Ranch (20 horses and mules). The upper watershed has been most affected by mining. There have been three separate gold booms in Dixie in 1864, the 1890s, and the 1930s. There are 23 inactive underground lode mines and one inactive open pit mine. The presence or extent of any toxic chemicals or acid mine drainage is unknown. Most of these mine disturbances have revegetated although there is still some sediment delivery from them as well as possibly from roads and associated millsites. There are nine inactive placer mines and 4.6 miles of dredged streams. Unvegetated tailings are still prominent. There are 13 underground lode mines in the Buffalo Hump area west of Big Creek, including the War Eagle Mine on Fitz Creek active in the 1930s. Unvegetated areas still exist in the Buffalo Hump area. Mining has slowed considerably since the 1930s although a resurgence in gold prices created increased mining activity in the sub-watershed in the 1980s (NPNF, 1994).

The upper ten miles of Crooked Creek to its headwaters is predominantly low gradient (<4%) with moderate to low entrenchment and a substrate of sands and small gravels. A survey conducted in 1987-88 revealed high existing sediment deposition (cobble embeddedness ranging from 53 to 67%), low pool to riffle ratios, and a lack of woody debris in the upper portions of Crooked Creek (NPNF, 1999a). Common stream habitat types include riffles, runs, dammed pools, and lateral scour pools. The stream channel of upper Crooked Creek is in poor condition with large amounts of sediment moving through the system (NPNF, 1999a). Near Big Creek, sediment deposition tops banks. Between the wilderness boundary (near Big Creek) and Lake Creek, Crooked Creek has apparent cobble embeddedness and sediment deposition in low gradient reaches, but much less than observed upstream. Within the wilderness area, stream gradients range from 5 to 15%, entrenchment is high and the substrate consists of large rubble and boulders, with little sediment deposition. Numerous plunge pools exist with steep cascades and pocket water.

JERSEY CREEK (1998 303(d) Listed for Sediment)

Jersey Creek is a high energy, third order tributary that is approximately nine miles long. Estimated mean annual discharge is 21 cfs, with the highest mean monthly discharge of 85 cfs occurring in May and a minimum mean monthly discharge of 5.3 cfs in October. Only a small portion of the lower drainage is in wilderness (12% of total), and the remaining drainage is strongly influenced by fire and fire suppression. Since 1960, 35% of the watershed has been affected by fire. Vegetation is considered moving towards unnatural, fire-suppressed condition. Ninety-six (96) acres were clear-cut in 1985 and there is evidence of past mining activity in the watershed. Roads total 18 miles used to access mining claims and for recreation. Light grazing has occurred throughout the watershed; heavy grazing is unlikely due to topography (NPNF, 1994).

The lower reaches of Jersey Creek are very steep with slopes averaging 15%. The channel is 100% A-type with a boulder and large rubble substrate. Cobble embeddedness is very low in the lower reaches, but very high in the upper part of the watershed. Given the amount of sediment in the upper watershed, suspended sediment may be high during spring and thunderstorm runoff events.

LITTLE MALLARD CREEK (1998 303(d) Listed for Sediment)

Little Mallard Creek watershed is entirely outside of wilderness boundaries. The creek is a third order stream approximately eight miles long just downstream of the Big Mallard confluence with the mainstem Salmon. Estimated mean annual discharge is 18 cfs, with a maximum mean monthly discharge of 73 cfs in May and a minimum mean monthly discharge of 3.5 cfs in September. Since 1960, only 16 acres have been burned, again suggesting that fire suppression has played a major role in vegetation development in the watershed.

Little Mallard Creek watershed is predominantly composed of National Forest lands and mostly roadless. There are 120 acres of private land in the watershed, three acres of which are used for residences and subsistence agriculture, and the remaining 117 acres are in scenic easement. Water diversion from Little Mallard Creek is used for long-term hydropower. Significant human activities on National Forests lands include: exploratory mining, domestic livestock grazing, and limited timber harvest in or near the headwaters (USFS, 1999). There are 13 miles of road in the watershed, the majority of which have been built since 1991 to access the Noble Timber Sale. Approximately five acres of the headwaters of Little Mallard Creek were placer mined in the 1980s. As a consequence, 400 yards of stream channel were impacted and remain unvegetated. Since 1984, light grazing by 22 horses and mules has occurred within 8,215 acres of the watershed. This level of grazing has occurred here since 1946, although there may have been some damage from overgrazing in the 1970s (NPNF, 1994).

The lower 3/4 mile of Little Mallard Creek is a highly confined A-type channel, with cascades, plunge pools, and riffles. The substrate is predominantly bedrock, boulders, and large cobbles. Cobble embeddedness is less than 25%. A hydropower facility reconstructed in 1993 on private property was contributing sediment to the lower reach in 1994. The upper portion of Little Mallard Creek by contrast is a low gradient sediment storage area. Due to the undeveloped nature of the watershed, the upper reaches are considered to be in near natural condition (see Table 7 for percent fines).

RABBIT CREEK

Rabbit Creek is a small sub-watershed located between California Creek to the west and Warren Creek to the east. The lower portion (approximately one mile) of Rabbit Creek is within wilderness boundaries. The sub-watershed includes Indian Creek on the north side of the Salmon River. Indian Creek is located between Crooked Creek to the west and Jersey Creek to the east. Indian Creek is almost entirely outside of wilderness boundaries. Very little information was available on this sub-watershed.

RHETT CREEK (1998 303(d) Listed for Sediment)

Rhett Creek is a third order stream approximately 10 miles in length. Estimated mean annual flow is 26 cfs, maximum mean monthly discharge is 110 cfs in May and minimum mean monthly discharge is 5 cfs in September. There are 861 acres of wilderness and 349 acres of private land in the watershed. All private land resulted from mining patents. These areas were mined primarily during the 1890 to 1930s. The Black Diamond Mine is active in the drainage and contributes an unknown amount of sediment to a tributary of Rhett Creek (Clearwater Basin Bull Trout Technical Advisory Team, 1998). Timber harvests have occurred and are planned for these private lands, and recreational homes are located there as well. Additional mining activity within the drainage include seven inactive underground lode mines and limited placer mining. Approximately 1,280 acres in the headwaters are grazed as part of the Little Mallard Allotment. Since 1960, no fires have burned in the drainage, and fire suppression may lead to vegetation replacement and possible high intensity, stand-replacing fires. Road density for non-wilderness land is 1.6 miles per square mile (NPNF, 1994).

The lower mile of Rhett Creek is an A-type channel with a small boulder and large and small cobble substrate. Cobble embeddedness is 20-30% in this lower stretch, but much higher in the upper watershed due to mining activities. Cobble embeddedness may be increasing in the upper reaches. Development of Robinson Dike Mine in the late 1980s resulted in a substantial increase in sediment input to Comstock Creek, a tributary to Rhett Creek (NPNF, 1994). In 1994, the site continued to be a source of sediment. Since Rhett Creek does not have a natural sediment storage area, it could be anticipated that sediment will move through the system to lower reaches.

SABE CREEK

Sabe Creek originates near Sabe Mountain at an elevation of 6,600 feet. The large, high energy stream is about 17 miles long, and has an estimated mean annual discharge of 120 cfs. The estimated mean monthly flows are estimated to range from 31 cfs in January to 444 cfs in June. Ninety-nine percent (99%) of the sub-watershed is in wilderness; only a road corridor at the very top of the drainage is outside wilderness boundaries. The lower third of the drainage is in LFG-3 and the upper two-thirds is in LFG-4. Since 1960, 38% of the sub-watershed has been affected by fire. There have been no recorded timber harvests and there is no private land within the sub-watershed. There is no recorded mining activity within the drainage although it is likely that exploratory activity took place at the mouth of Sabe Creek. The single road at the top of the drainage traverses 11 miles of its border and is used for recreational purposes. Historic grazing has likely been a predominant activity in the sub-watershed. Grazing has been authorized rather continuously in the Bear Point region (upper breaklands) since 1960 (NPNF, 1994).

SHEEP CREEK

Sheep Creek is a large, high energy system almost entirely within the Gospel Hump Wilderness. Sheep Creek originates near Buffalo Hump at approximately 8,000 ft. elevation and is about 17 miles long. Estimated mean annual discharge is 69.5 cfs with estimated mean monthly flows as low as 25 cfs in January and as high as 246 cfs in June. There are a few miles of road associated with turn-of-the-century mining. There were 19 mining claims on 556 acres of private land, none of which are active today. Grazing has occurred in the sub-watershed since 1910. Although heavy at times, recent grazing management activity has allowed a general upward trend in vegetation condition. No grazing has occurred since 1987. Fire has affected 27% of the sub-watershed since 1960, some which has been locally intense. The majority of the sub-watershed is in alpine glaciated lands (Landform Group 4) (NPNF, 1994).

WARREN CREEK (1998 303(d) Listed for Sediment)

Warren Creek sub-watershed is a large drainage (57,500 acres) on the south side of the Salmon River. The creek itself is 21 miles long and predominantly high gradient and energy, although there is a pronounced lower gradient meadow area that has been extensively dredge mined. Warren Creek originates near Warren Summit at about 7,000 feet elevation. Summer discharge is estimated to be around 23 cfs. The lowest three miles of Warren Creek are within wilderness boundaries. Approximately 8.5% of the sub-watershed is private land including much of the dredged stream areas near Warren. There have been small amounts of timber harvesting, grazing and fire suppression.

A long history of mining activities has affected the upper part of the sub-watershed. Mining began in the late 1800s, and continued through the 1930s when substantial impacts occurred from placer and lode mining. Historic and active mining in the Warren Creek drainage has resulted in many ore and/or tailings piles bordering streams in the mined portions of the watershed. Natural vegetation recovery has been poor because of the lack of topsoil. Some sections of Warren Creek have been dredge mined in the past. The tailings and the dredge deposits are presumably the reason for listing this stream for habitat alteration. There are four active lode mines in the sub-watershed, three of which show current activities taking place. Other activities occur in the Warren Creek watershed, including timber harvesting, outfitter and guide use, recreation, road and trail use. There are about 70 miles of road in the watershed (density = 1 to 2 miles/square mile), some of which are old (50 years) roads built to access mines. There is apparently some sediment contribution to the stream from these roads. (Clearwater Basin Bull Trout Technical Advisory Team, 1998; PNF, 1999) Many of the tributaries to Warren Creek have excessive fine sediment (PNF, 1995).

The lower one to two miles of Warren Creek are A-type channels with gradients averaging 6.1% and as high as 12%. The substrate is primarily boulders and cobbles. Streambanks are more than 98% stable and the width to depth ratio is 21.6. Above 2.4 miles the gradient becomes steeper (9.4%) and the channel is characterized by boulders and high gradient riffles. At mile ten the gradient becomes 6.9%. Moving upstream to the mouth of Schissler Creek, Warren Creek becomes a C-type channel with non-turbulent units and lateral scour pools. For the remainder of Warren Creek to its headwaters, dredge piles confine the stream to A- and B-type channels. At the Warren meadows area, gradients are low (0.4-0.5%). The dredged areas lack pools, winter habitat, overhead vegetation, and woody debris. Fine sediment reaches 15% in this low gradient area.

WIND RIVER

Wind River is a fairly large drainage (41,348 acres) on the north side of the Salmon River. Sixty-eight percent of this watershed is in the Gospel Hump Wilderness. The Meadow Creek section of Wind River watershed is 60% outside of wilderness and has experienced a number of human activities. Average annual discharge from Wind River is estimated to be 88.6 cfs with mean monthly flow ranging from an average of 23 cfs in January to 328 cfs in June. The drainage averages B-type channels, 30 feet wide and 3 feet deep, which vary from 4 to 30% gradient (NPNF, 1999a). Since 1950, 22% of the sub-watershed has been affected by fire. Wind River has been affected by mining in the Meadow Creek drainage and grazing in the upland and headwater meadows.

There are approximately 49 miles of road used to access past mining and timber harvesting areas. Timber harvesting has occurred on 1812 acres mostly in the 1980s. Historic grazing dates back to 1861. There are two grazing allotments that have been vacant since 1987 and 1992. One allotment continues with active grazing in the Wind River Meadows area. There has been some damage to the vegetation in some areas of this sub-watershed. Past mining in the Florence Basin (Meadow Creek) has been extensive. Placer mining began in 1860 and lode mining began in the 1890s after placer mining slowed down. Placer mining activity increased again in the 1930s. After this time, activity slowed but has been continuous ever since. Miles of trenches have been dug to supply water to placer operations. One small open pit mine was started in the 1950s and has been worked off and on ever since. Mercury was used to extract gold from ore, and a spill was reported in 1983. Contaminated material was moved to an impermeable liner in 1986 (NPNF, 1994). Water sampling to detect mercury was done in 1995 to 1996 by Forest Service and DEQ personnel. Mercury was not detected in monitoring wells or any surface waters. However, sludge from the pond bottom had mercury levels of 6.86 ppm, 0.98 ppm, and 3.96 ppm in three samples taken by DEQ.

WATER QUALITY CONCERNS AND STATUS

WATER QUALITY-LIMITED WATERS

There are eight stream segments listed as water quality-limited on the 1996 303(d) list for this subbasin (Table 8). Six streams are listed for sediment pollution, all of which are in the vicinity of Dixie between the two wilderness areas (Map 11−303(d) Listed Stream Segments). Warren Creek on the south side of the Salmon River is listed for habitat alteration. The Salmon River itself is listed from Corn Creek to Cherry Creek for unknown pollutants.

The 1996 303(d) listing, exacted by EPA as a result of a lawsuit, included the Salmon River from Corn Creek to Cherry Creek reportedly because this section of the river was identified in Appendix D of Idaho's 1992 305(b) report. EPA indicated that it was also a Stream Segment of Concern (SSOC), although it was not found in SSOC reports (State of Idaho, 1989, 1992).

Appendix D of the 1992 305(b) report (DEQ, 1992), however, indicated that the Idaho Department of Fish and Game (IDFG) requested listing this section of the Salmon River as only partially supporting cold water biota and salmonid spawning due to moderate impacts from agricultural, timber harvesting, construction (including roads), and mining activities. However, we are not aware of data to substantiate this claim. Information included in Appendix D of the 1992 305(b) report was sometimes based on conjecture and was to be used only for guiding further assessment needs.

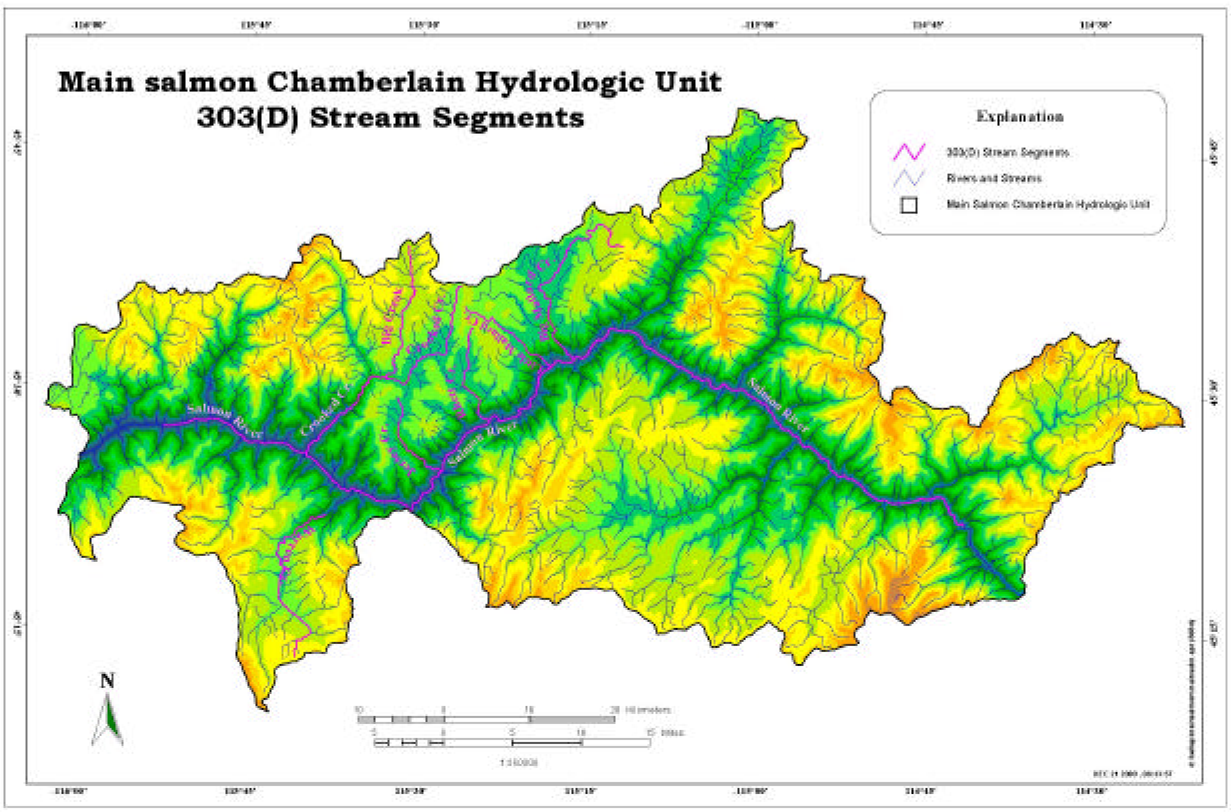
Table 8. Water Quality-limited Waters in Subbasin.

Water Body Name	Boundaries	Pollutants
Big Creek	Headwaters to Crooked Creek	sediment
Big Mallard Creek	Headwaters to Salmon River	sediment
Crooked Creek	Headwaters to Salmon River	sediment
Jersey Creek	Headwaters to Salmon River	sediment
Little Mallard Creek	Headwaters to Salmon River	sediment
Rhett Creek	Headwaters to Salmon River	sediment
Warren Creek	Headwaters to Wilderness Boundary	habitat alteration
Salmon River	Corn Creek to Cherry Creek	unknown

IDFG=s concerns with sediment in the Salmon River stem from up-river contributions of sediment from primarily the South Fork Salmon River (Anderson, 1999), an area previously identified as having impacts from sediment. A sediment TMDL was completed for the South Fork Salmon River. According to IDFG, these upstream impacts may affect beneficial uses within the Salmon River itself through sediment deposition reducing over-wintering habitat and affecting chinook and steelhead spawning areas. However, no data could be found to substantiate these claims.

The NPNF (1994) indicates that a combination of erodible soils, fire history, and periodic intense climatic events result in substantial natural erosion and delivery of sediment to the Salmon River. They indicate that suspended sediment concentrations and turbidity in the Salmon River during spring months are often high enough to preclude visibility. These conditions most often associated with early spring rains at low elevations, and later during higher flows from snowmelt runoff. Such conditions can last for several weeks. They can also occur in the summer as a result of rainstorms and last for over a week.

Map 11. 303(d) Listed Stream Segments



The NPNF (1994) reported that data are very sparse, but there was some suspended sediment data from USGS collected 6 to 12 times a year from 1971 to 1991. During most years suspended sediment concentrations ranged from 2 mg/l to 65 mg/l, except during May when concentrations ranged from 6 mg/l to 503 mg/l. Most of the time the Salmon River is below 25 mg/l suspended sediment. However, spring runoff, rain-on-snow events, and intense summer rainstorms can cause suspended sediment concentration to significantly exceed 25 mg/l (NPNF, 1994). The NPNF (1994) indicated from the literature that the effects of these suspended sediment concentrations on salmonid fishes was variable and unclear, and they recommended overall that suspended sediment was of moderate importance to fish due to their evolved ability to tolerate or avoid such periodic high concentrations.

The NPNF (1994) indicated that bedload and deposited sediment conditions were even less well documented than suspended sediment conditions. The coarse material is generally deposited in alluvial fans which are gradually eroded by the river during high flows over a period of years. Also, the NPNF (1994) indicated that some reduction in pool volume, by filling with gravel and small cobbles, in this portion of the Salmon River, may have occurred as a result of upstream activities. The river apparently has tremendous capability to transport sediment ranging in size from sand to large cobble as evidenced by casual observations of sediment deposition. There has not been a serious amount of deposition along most of the riverbed from Sabe Creek to its confluence with the Snake River. Observations suggest that beach erosion occurs during low water years and beaches are replenished during high water years (NPNF, 1994).

Anecdotal observations of accelerated sediment yields to the Salmon River from Nez Perce National Forest activities suggest that these impacts have not significantly degraded river habitat (NPNF, 1994). According to the NPNF (1994), this appears to be largely due to the high transport capacity and relatively low additional sediment input beyond that from other sources, both natural and human induced. The primary evidence for this is the apparent lack of fines deposition below major tributaries, such as Crooked Creek. Where significant alluvial fans do exist at the mouths of Nez Perce National Forest tributaries, it is believed that they formed largely in response to natural events.

IDFG also suggested temperature as a possible problem to cold water biota beneficial use as the Salmon River does warm up above 22^{o}C in the canyon during the summer (Anderson, 1999). The Nez Perce National Forest, in their biological assessments for endangered salmonids, identified temperature as a concern as well (NPNF, 1994). If forest activities along the tributaries have reduced vegetation cover, thus warming the streams, they could affect mixing zone refugia and incrementally increase temperatures in the Main Salmon, affecting migrating anadromous salmonids (NPNF, 1994).

Temperature data for the Salmon River in this subbasin are sparse. Temperature data collected by USGS for the Salmon River near Whitebird periodically from 1976 to 1991 showed July temperatures between 28.0^{o}C and 16.5^{o}C (NPNF, 1994). These temperatures may not be indicative of temperatures in the Salmon River in this subbasin as a number of tributaries enter after this subbasin and the river is progressively exposed to more solar radiation as it flows downstream. Reingold in August 1969 sampled Salmon River water temperatures within the vicinity of this subbasin (NPNF, 1994). The six samples showed temperatures between 18^{o} and 20^{o}C. The Nez Perce National Forest measured Salmon River water temperatures at several locations within this subbasin from July to October during 1994 to 1998 (NPNF, 1999b). The 7-day moving average of maximum daily temperatures exceeded 22^{o}C for a short period of time in July, 1994; but were below this temperature in all other years. From these data it is likely that the cold water biota maximum temperature criterion (22^{o}C) was exceeded during July 1994, however not necessarily during the other months of 1994 nor during the other years (1995-1998). These data show fall water temperatures reached 13^{o}C (7-day moving average of maximum daily temperatures) about early October in the Salmon River. The USGS data at Whitebird showed Salmon River temperatures in May to be 9^{o} to 13.5^{o}C (NPNF, 1994).

Water temperatures in the Salmon River near Whitebird clearly exceed state water quality standards for cold water biota during the summer. But there is insufficient information to determine whether water temperatures in the Salmon River in the Salmon-Chamberlain subbasin exceed state water quality standards any more than during the occassional very hot year. Even though water temperatures are warm in the Salmon River during the summer, it would be difficult to separate the difference between temperatures (or heat loads) that are a natural phenomenon and those that are caused by human activities.

The tributaries were 303d listed for reasons similar to the Salmon River. In addition to the Salmon River, the 1992 305(b) report, Appendix D also included Crooked Creek and Warren Creek (IDEQ, 1992). The report indicated that Crooked Creek from the headwaters (mines) to Big Creek was partially supporting salmonid spawning and cold water biota was supported but threatened. Again, IDFG suggested the causes as low impacts from construction and moderate impacts from mining. Warren Creek, headwaters to the wilderness boundary, was identified by the USFS as partially supporting cold water biota due to low impacts from road construction and recreation, and high impacts from placer and dredge mining. IDFG identified Warren Creek as partially supporting cold water biota and salmonid spawning due to low impacts from agriculture and timber harvesting, moderate impacts from construction, and high impacts from mining. Again, information included in Appendix D of the 1992 305(b) report was based on conjecture and was to be used only for guiding further assessment needs.

Another source of information used by EPA to create the court ordered 303(d) list was the Nez Perce National Forest Watershed Condition Analysis (Gloss and Gerhardt, 1992). Meeting Forest Plan objectives may have wrongly influenced EPA's analysis for 303(d) listing. This analysis, designed to provide regional foresters with broad scale information on the condition of major (5th field) watersheds in 1992, used a rating scheme that was based on analyses of watershed sensitivity (rated low, moderate, or high), the district's determinations on the significance or insignificance of activities (grazing, mining, timber harvesting, other) in the watershed, the road density (low, moderate, or high), the percent of watershed disturbed (low, moderate, or high), and the watershed's proximity to meeting Forest Plan objectives (low, moderate, or high). It should be noted that the watershed analysis gave Crooked Creek a low concern rating, which is in contrast to the 1996 303(d) listing.

Although the Forest Plan objective rating scheme was based on water quality habitat parameters, there were no comparisons made to the state's water quality standards or assessment processes. For example, a determination of existing condition relative to Forest Plan objectives included parameters such as cobble embeddedness, large woody debris, and bank stability that do not have directly comparable surrogates in the state's water quality standards. The fact that watersheds were not meeting forest plan objectives does not necessarily indicate that they were not, or are not now, meeting water quality standards. In fact, it is quite possible that a stream may meet water quality standards, but the Forest Plan had desired future conditions unrelated to these standards that the stream did not meet in 1992.

WATER QUALITY STANDARDS

Designated beneficial uses (as per IDAPA 58.01.02.130.09) for waters in the Salmon-Chamberlain subbasin are listed in Table 9. All tributaries to the Salmon River are undesignated waters at the time of this writing. Undesignated waters are presumed to support cold water biota and primary or secondary contact recreation, and will be protected for these uses until such time as the waters are officially designated for beneficial uses (see IDAPA 58.01.02.101).

Water quality criteria used to protect these beneficial uses include narrative free form criteria applicable to all waters (IDAPA 58.01.02.200), and numerical criteria which vary according to beneficial uses (IDAPA 58.01.02.210, 250, 251, 252). Typical numeric criteria include bacteriological criteria for recreation uses, physical and chemical criteria for aquatic life (e.g. pH, temperature, DO, ammonia, toxics, etc), and toxics and turbidity criteria for water supplies.

Of particular importance regarding listed water bodies in this subbasin is the narrative criterion for sediment (IDAPA 58.01.02.200.08) as follows:

> "Sediment shall not exceed quantities specified in Section 250 and 252, or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses. Determination of impairment shall be based on water quality monitoring and surveillance and the information utilized in Section 350."

Table 9. Designated Beneficial Uses.

Map Code	Water Body	Designated Uses
S-1	Salmon River - South Fork Salmon River to river mile 106	Domestic Water Supply, Agricultural Water Supply Cold Water Biota Primary Contact Recreation, Secondary Contact Recreation Special Resource Water
S-8	Salmon River - Chamberlain Creek to South Fork Salmon R.	Domestic Water Supply, Agricultural Water Supply Cold Water Biota, Salmonid Spawning Primary Contact Recreation, Secondary Contact Recreation Special Resource Water
S-18	Salmon River - Horse Creek to Chamberlain Creek	Domestic Water Supply, Agricultural Water Supply Cold Water Biota, Salmonid Spawning Primary Contact Recreation, Secondary Contact Recreation Special Resource Water
S-37	Salmon River - Middle Fork Salmon River to Horse Creek	Domestic Water Supply, Agricultural Water Supply Cold Water Biota, Salmonid Spawning Primary Contact Recreation, Secondary Contact Recreation Special Resource Water

Quantities specified in Section 250 refer to turbidity criteria identified for cold water biota use and small public domestic water supplies. Indirectly, specific sediment criteria also include intergravel dissolved oxygen measures for salmonid spawning uses. Intergravels filled with sediment cannot hold enough dissolved oxygen for successful egg incubation. Turbidity must be measured upstream and downstream from a sediment input in order to determine violation of the criteria. Intergravel dissolved oxygen measures require the placement of special apparatus in spawning gravels. Both measures are rarely conducted as a part of routine reconnaissance level monitoring and assessment. These measurements are usually conducted in special cases during higher-level investigations of potential problems. Because of access difficulty, such techniques are rarely used in the back-country settings comprising most of this subbasin.

Theoretically, any stream with sediment pollution exceeding water quality standards will require a total maximum daily load (TMDL). In practice, the relationship between sediment and its effects on beneficial uses is not clearly understood. Although there are some criteria that are indicators of specific sediment-related problems (like turbidity and intergravel dissolved oxygen), the level of sediment necessary to cause an effect and actually violate water quality standards is not defined. Nor is it likely to be the same in all locations due to differences in geology and hydrology.

As indicated in the state's water quality standards (IDAPA 58.01.02.350), nonpoint source pollution is addressed through a feedback loop approach where best management practices (BMP) to control sediment are put into place, and evaluations are made to see if the practices are working. If they are not working, or if beneficial uses do not recover, then the BMPs are modified, and re-evaluated until successful. It is likely that an *adaptive management approach* will need to be taken to determine the level of sediment control necessary for a sediment TMDL. Adaptive management allows for initial sediment reduction targets to be set and the feedback loop used to monitor and assess the progress of sediment reductions towards improving the beneficial uses. When it is unknown how much sediment affects a beneficial use, only through the repetitive process of control and monitoring will appropriate results be achieved.

WATER BODY ASSESSMENTS

Beneficial Use Reconnaissance Project

Fourteen streams in this subbasin have been monitored using the DEQ Beneficail Use Reconnaissance Project (BURP) including all 303(d) listed streams. DEQ attempts to monitor streams in at least two locations, the upper part of the watershed and as close to the mouth as possible. Of the seven 303(d) listed streams in the subbasin, four were sampled in two locations and three were monitored in only one location. All streams except Rhett Creek were sampled close to the wilderness boundary within several miles of the mouth. It is expected that most BURP sites represent integrating reaches and will reflect the cumulative effects of disturbances in these watersheds. Rhett Creek was sampled once in the middle of the watershed.

Streams in this subbasin assessed through the DEQ Beneficial Use Reconnaissance Project (BURP) and the 1996 Water Body Assessment Guidance or "WBAG 1" as it is called (IDEQ, 1996) plus any additional information are listed in Table 10. For all of these streams, macroinvertebrate index scores (MBI) were calculate using the new 2000 calculator and habitat index scores were calculated using the 1996 process. Salmonid spawning beneficial use was assessed from BURP electrofishing data and/or from Forest Service information (Mays, 2000). A final assessment determination was made by comparing MBI and HI scores, fish age class data and other available data regarding criteria exceedances to pre-determined acceptable levels. From this analysis, streams were determined to be "full support," "needs verification," or "not full support" for cold water biota and salmonid spawning.

All streams except Cramer Creek would receive a "Full support" status for cold water biota based on the data in Table 10. MBI and HI scores were generally high reflecting the near pristine quality of these streams. The streams that had fish data would likewise receive a "full support" rating for salmonid spawning use. All streams with fish data had at least two age classes of salmonids and habitat scores greater than 73, which is needed for a full support rating on salmonid spawning (see Appendix 4). In fact, many of these streams had at least three age classes of salmonids and HI scores greater than 90.

Table 10. Water Bodies Assessed Through BURP.

Water Body	Fish Data	MBI*	HI	Support Status#
Noble Creek	Cutthroats multiple size classes (BURP)	5.57	111	Full Support CWB and SS
Eutopia Creek	No data	4.77	102	Full Support CWB
McGuire Creek	No data	4.68	111	Full Support CWB
Big Creek (303d listed)	Rainbows and hybrids spawning and early rearing (Mays, 2000).	5.07(L) 4.61(U)	105 115	Full Support CWB and SS
Jersey Creek (303d listed)	Cutthroat spawning and rearing, steelhead rearing (Mays, 2000). Rainbows 3 size classes (BURP).	4.93	127	Full Support CWB and SS
Rhett Creek (303d listed)	Salmonids - multiple age classes above and below barrier (Mays, 2000). Cutthroat 3 size classes (BURP).	5.13	92	Full Support CWB and SS
Warren Creek (303d listed)	No data	4.99(U) 4.93(L)	94 90	Full Support CWB
Crooked Creek (303d listed)	Salmonids - multiple age classes above and below barrier (Mays, 2000)	4.92(L) 4.46(U)	94 99	Full Support CWB and SS
Big Mallard Creek (303d listed)	Brook trout multiple size classes (BURP).	5.06(L) 5.31(U)	103 108	Full Support CWB and SS
Little Mallard Creek (303d listed)	Barrier near mouth, no fish	4.25	118	Full Support CWB
Corn Creek	No data	5.07	111	Full Support CWB
Bear Basin Creek	No data	4.02	99	Full Support CWB
Cramer Creek	No data	3.17	75	Needs Verification

* Macroinvertebrate Biotic Index (MBI) scores were calculated using the 2000 version calculator representing the latest inclusion of macroinvertebrate species.
# CWB = cold water biota; SS = salmonid spawning.

Macroinvertebrate and habitat scores were marginal for Cramer Creek (3.17 and 75, respectively). The low habitat score and the general condition of Cramer Creek were probably affected by its low flow (0.6 cfs) at the time of assessment. Such low flow conditions in general tend to preclude cold water biota as a result of a lack of water, increased temperatures, reduced dissolved oxygen, and the lack of substrate. The Cramer Creek macroinvertebrate sample had low species diversity (15 species) and percent dominance was high at 69%. However, the sample was dominated by one Plecoptera taxon indicative of better quality cold water streams. In fact, 75% of the taxa were stoneflies. Most of the other taxa in the sample were relatively tolerant species. This suggests that the stream exists in a state of flux between a good quality cold water stream and one that is compromised by low flow conditions. Cramer Creek should be re-assessed to determine if it should be classified as an intermittent water.

Early in 2002, the second edition of DEQ's Water Body Assessment Guidance was released. This WBAG II protocol modified considerably the process by which streams are assessed for support of beneficial uses. Specifically, multimetric indices were changed as more data were added since WBAG 1 was published. A process was put in place where macroinvertebrate, habitat, and fish indices are scored and then averaged to produce a single score from 0 to 3 where streams must score a 2 or higher to be considered fully supporting their aquatic life uses. Data from BURP sites in this subbasin were re-evaluated using this new WBAG II system. Those resulting indices and scores are presented in Appendix 8. As was demonstrated with the earlier WBAG 1 process, all streams except Cramer Creek showed cold water aquatic life use fully supported.

Water temperature was measured at several locations in Crooked Creek from 1994 to 1998 (NPNF, 1999b) (see Appendix 4). Temperatures exceeded 22^{o}C only slightly in 1994, but not in following years. Water temperatures exceeded 13^{o}C from late June to mid to late September in every year. BURP crews measured an instantaneous value of 15^{o}C in upper Crooked Creek on July 14, 1997. These measurements exceed the salmonid spawning maximum temperature of 13^{o}C. However, it is questionable whether this time period is reflective of natural spawning timing for rainbow and cutthroat trout found in this stream. Bull trout spawning and rearing temperature criteria would be exceeded by these data. The Bull Trout Problem Assessment (Clearwater Basin Bull Trout Technical Advisory Team, 1998) determined that past activities have affected the temperature of upper Crooked Creek to preclude bull trout spawning. However, the Forest Service (NPNF, 1999a) suggests that a possible migration barrier at approximately 3/4 mile downstream of the Big Creek confluence may have precluded bull trout from the upper watershed anyway.

Bull trout spawning temperature exceedances in lower Big Mallard Creek and lower Little Mallard Creek were detected in temperature data obtained from NPNF (1999b) (see Appendix 4). Water temperatures need to be below an instantaneous maximum of 13^{o}C and a daily average of 9^{o}C on and after September 1st for bull trout spawning. During the summer, bull trout rearing habitat needs to be below an average daily water temperature of 12^{o}C. It is not clear from the data (NPNF, 1999b) if water temperatures in the mouths of these two creeks exceed the daily average; however, they do exceed 13^{o}C during September. However, the mouths of these two creeks may not be salmonid spawning areas. Therefore, the applicability of salmonid spawning temperature criteria during September at these two locations is questionable. More information is needed on the temperature regime of the entire stream before potential impacts to salmonid spawning could be determined.

Additionally, macroinvertebrate samples from BURP efforts within the subbasin were further analyzed to assess relative impacts from fine sediment (Clark, 2000); see Appendix 1). This report concluded that, on a relative scale, Big Creek, Big Mallard Creek, and Rhett Creek appear to be in better condition than Crooked Creek, Jersey Creek, Warren Creek, and Little Mallard Creek. These conditions were based on macroinvertebrate assemblage characteristics such as taxa richness, numbers of Plecoptera taxa, and numbers of cold water indicator species. Both Crooked Creek and Warren Creek have been affected by past dredge mining activities and these legacy issues remain.

Nez Perce National Forest Assessments

The Main Salmon River Subbasin Biological Assessment (NPNF, 1999a) examined an area from the Little Salmon River to Sabe Creek, which includes only part of the Salmon-Chamberlain subbasin. This document described the most impacted areas to generally be the area west of Wind River (including the Meadow Creek area of the Wind River drainage), the Marshall Mountain mining area, and the upper Crooked Creek drainage. There are areas within the subbasin that have been altered by past mining activities, road construction, and grazing. Logging accounts for a small percentage of the human activities in the subbasin, generally less than 1% of the subbasin or 2% of the non-wilderness/non-roaded area. A summary of areas of concern for sensitive salmonids indicated that Warren and upper Crooked Creeks were targets for rehabilitation (NPNF, 1999a). The Nez Perce National Forest has recommended that it will work with local land owners in Dixie and the Idaho Department of Fish and Game to build a long-term aquatic restoration strategy for upper Crooked Creek (NPNF, 1999a). Currently, no restoration activities are planned in the area because of other high priority needs in the Forest. Table 11 presents the overall assessment of baseline conditions described on pages 36-39 of the Biological Assessment (NPNF, 1999a).

The U.S. Geological Survey has maintained a gaging station on the Salmon River at the mouth of White Bird Creek since 1910. As part of the response for *Term and Condition Number Four* of the AMain Salmon River Tributaries Northeast Biological Opinion≅ (NPNF, 1999b), the Nez Perce Forest Service addressed several components affecting listed aquatic species. One particular component was to establish baseline conditions related to sediment yield and concentration for the Salmon River from Sabe Creek to the Little Salmon River confluence based on available scientific information. The combination of collected sediment samples at the gaging station and further, modeling using NEZSED, BOISED, and unit area estimations were used to estimate the total annual sediment yield for the entire drainage. Sediment yields are predicted from natural sources, as well as from timber harvests and roads. The assumptions used in these modeling exercises are many and great, and there is a great deal of uncertainty associated with the figures. Interpretation should be cautious and the results treated as crude estimations at best (NPNF, 1994). At the White Bird gaging station, the total annual sediment yield was estimated at 530,000 tons/year. In using an Aarea-based proportion,≅ the sediment yield was estimated to be 490,000 tons/year, above Riggins (Table 12) (Gerhardt and Thompson, 1997).

Table 11. Overall Assessment for Middle Salmon-Chamberlain Subbasin (NPNF, 1999a)*.

Characteristic	Subbasin Overall	Specific Waters
Road density	<1mi/mi^2	Carey, Fall = 1 - 2.2 mi/mi^2 Jersey = 1 - 2.9 mi/mi^2 Meadow (Wind) = 3.4 mi/mi^2
Riparian Vegetation	high condition	Meadow(Wind) = moderate
Width/Depth Ratio	moderate condition	Big Mallard, Crooked, Carey = moderate southside watersheds = low
Streambank Stability	good condition	northside (except Wind Meadow) = 95-100% stable, southside (except Lake) high condition
Temperature (for Steelhead rearing)	natural conditions	northside (except Crooked, Bargamin, face streams) = 14^{o}C, lower elevation low to mid reaches = 16.8 - 18.5^{o}C
Cobble Embeddedness	highly variable	northside = high to moderate, upper Crooked = high, lower Crooked = low to moderate, Bargamin, Wind, face streams = <20%, Big Mallard, Partridge, Elkhorn, French, face(uplands) = 20-35%, Fall = >35%
Large Woody Debris	natural levels	Warren = below natural levels
Pool Frequency	low in 9 of 12 watersheds	California Cr. only one not meeting minimum standards for salmonids. Placer dredge mined creeks (Warren, Crooked) probably lack pools as well.
Fish Passage Barriers	no human made	except for several culverts on Road 1614.
Off Channel Habitat	high condition	low condition in Allison and face drainages from Wind to Berg.
Habitat Refugia	generally abundant	Big Mallard lacks refugia because of barrier and channel type.
Chemical Contamination	very little	Warren has potential, Warren may have sources of metals in soil and ground water.

*Environmental baseline information provided by NPNF, 1999a includes condition ratings of "high, moderate, and low" which we interpret to mean good condition, moderate condition and poor condition, respectively. However, caution should be used in interpreting this information. We recommend the reader consult NPNF, 1999a for interpretations and assumptions used in these environmental conditions.

Table 12. Main Salmon River sediment yield summary (Gerhardt and Thompson, 1997)**.

Analysis Point	Drainage Area (sq. mi)	Accrued natural (t/yr)	Accrued activity (t/yr)	Total (t/yr)	Rate*
below White Bird	13,550	N/A	N/A	530,000	39.1
Above Little Salmon	12,518	104,000	12,800	490,000	39.1
below Crooked Creek	12,011	87,500	12,200	473,000	39.4
below Big Mallard Creek	10,268	9,500	61	383,000	37.3
Above Sabe Creek	9,909	N/A	N/A	373,000	37.7

* The units for Rate = tons/square mile/year.
** The assumptions used in NEZSED modeling are many and great, and there is a great deal of uncertainty associated with the figures. Interpretation should be cautious and the results treated as crude estimations at best (NPNF, 1994).

Sediment production from lands managed by the Nez Perce National Forest was estimated using the NEZSED model. The natural sediment yield for the north side of the Salmon River from the Little Salmon River to Sabe Creek was estimated at 19,200 tons/year. Activity-related sediment yield was estimated at 260 tons/year or about 0.05 percent (260/530,000) of the annual sediment yield of the river above Riggins. The total contribution from activity-caused sediment from actions within the Nez Perce National Forest to the mainstem Salmon was concluded to be minimal (NPNF, 1994, 1999a, Gerhardt and Thompson, 1997). Based on these calculations, it was estimated that 117,000 tons/year entered from all sources and tributaries the area between Sabe Creek and Little Salmon River (490,000 - 373,000 = 117,000) (Gerhardt and Thompson, 1997). Of this total, 104,000 tons/year is estimated to be natural and 12,800 tons/year are due to activities. Of the accrued sediment yield (117,000 tons/year), about 65% or 76,050 tons/year was estimated to be from the South Fork Salmon River. The South Fork is also the source of an estimated 92% of the accrued activity sediment yield (92% of 12,800 tons/year = 11,776 tons/year), assumed to be mostly from roads. (Gerhardt and Thompson, 1997). That means only 1,024 tons/year (12,800 – 11,776 = 1,024) of sediment accrue from activities in the main Salmon River watershed from Sabe Creek to the Little Salmon River.

A summary of NEZSED model runs for the Nez Perce portion of the subbasin (Paradiso, 2000) is contained in Appendix 2. The tables in the appendix present natural sediment yield and activity yield as predicted by the model. Percent over base for the 303d listed watersheds vary from 0.7% to 4.4%. Percent over base is defined as activity yield/natural yield times 100 (see Appendix 2 for further definitions). Some watersheds are broken down into smaller component watersheds on subsequent tables in the appendix. For example, upper Crooked Creek produced an output of 24% over base, whereas the entire Crooked Creek drainage was estimated at 4.4% over base. A yield of 24% is considered well within the range of variability of the analysis. Thus, such a yield may not represent a significant departure from natural levels. Again, interpretation of these data should be viewed with caution because of uncertainty with assumptions and estimations.

The Nez Perce National Forest has had an active sediment monitoring program in the subbasin since 1995 in the rolling uplands of Big and Little Mallard Creeks (NPNF, 1999b). The sediment monitoring consists of three parts: A) monitoring deposited sediment levels near project areas in the upper watersheds of Big and Little Mallard Creeks; B) monitoring of the Sinker minerals projects; and C) monitoring deposited sediment levels in the lower stream reaches that contain chinook habitat. Sampling has focused predominantly on the area between the given timber-related activities and the spring/summer chinook habitat in Big and Little Mallard Creeks.

The project area activities chosen to monitor include the Grouse, Noble, and Jack timber sales. Timber sale roads and harvest have been completed for these activities. The Grouse and Jack timber sales are located entirely within Grouse Creek and Jack Creek watersheds, both of which are tributaries of Big Mallard Creek. The Noble timber sale is located within the Little Mallard Creek watershed. Within each case, all road construction and timber harvesting were completed between 1992 and 1998.

Pebble count data for fixed transects, averaged for all water types, and collected in conjunction with these timber sales are summarized in Table 13. Percent fines (<6mm) are variable, but generally less than 40% for most sites. Stream monitoring indicated an overall decrease in the percentage of pebble count samples composed of substrate less than 6 mm at all of the monitoring sites from 1995 to 1998 (NPNF, 1999b). The report concludes, however, that four years of data is insufficient to test for trends. At a minimum, several years of additional data would be necessary to draw on presence/absence trends for deposited fine sediment in the streams monitored within Big and Little Mallard Creeks (NPNF, 1999b). Further, the current sampling site design, considered cumulative effects monitoring sites, is recognized as being inadequate to ever conclude whether a sediment trend at the sites could be tied to a number of activities related to roads, grazing, timber harvest, etc (Table 14). In the future, it is recommended by NPNF (1999b) that sampling focus on these activities through road and harvest reviews or other upslope monitoring methods to establish the need for implementing forest practices source control measures and other immediate mitigation measures (e.g., Forest Practices Cumulative Watershed Effect Process).

Table 14 summarizes all road miles, road density (mi/mi^2), and harvested acres, for the specified prescription watersheds (represented by a single watershed number and name). Generally, the equivalent clear-cut acres are less than 2 percent of Harvest %. The data contained within the table is as of February 1998.

Water samples for turbidity were collected in Crooked Creek near the Dixie Work Center (NPNF, 1990a). Turbidity ranged in values from 0.5 to 10 Jackson units, which are too low to be considered violations of state water quality standards for turbidity. These measurements were considered Aspot≅ and not taken from a representative context for monitoring critical conditions. Cobble embeddedness surveys in 1989 did conclude that upper Crooked Creek has relatively high cobble embeddedness (Table 15), although baseline natural embeddedness was considered lower than most other streams (NPNF, 1990a). Owing to disturbances being relatively light, the Nez Perce Forest speculated that the high cobble embeddedness in these creeks was due to natural geologic conditions, past fire history, low gradient channel reaches, and low sediment flushing rates (NPNF, 1990a). A high percentage of natural and existing cobble embeddedness was also reported for prescription watersheds within the Big

Mallard Creek drainage (i.e., Jack and Noble Creeks), as well as the Little Mallard Creek drainage.
Table 13. Summary of pebble count data (as % <6mm) for fixed transect locations averaged over all water types (slow to fast) (NPNF, 1999b).

Stream Name	Range of percent (%) fines (<6mm)
Little Mallard Creek below Noble timber sale	17 to 35
Little Mallard Creek below Sinker Mine	64 to 78
Little Mallard Creek site #9	2 to 12
Big Mallard Creek below Grouse Creek	19 to 21
Big Mallard Creek above Jack Creek	25 to 36
Big Mallard Creek above Slide Creek	35 to 48
SF Big Mallard Creek	24 to 46
Big Mallard Creek site #10a near mouth	1 to 11
Big Mallard Creek site #10b near mouth	6 (1998 only)
Grouse Creek	32 to 49
Jack Creek	74 to 80
Bargamin Creek	17 to 26

Table 14. Cumulative watershed accounting of management activities within Big and Little Mallard Creeks (NPNF, 1999b).

Watershed Name	Acres	Road miles	Road density	Harvest acres	Harvest %
Noble Cr.	7,283	10.7	0.94	271	4
Grouse Cr.	1,230	2.0	1.04	148	12
Jack Cr.	4,265	11.9	1.78	109	3
Middle Big Mallard Cr.	5,057	8.9	1.13	11	0
Upper Big Mallard Cr.	4,444	3.3	0.47	164	4
SF Big Mallard	4,622	0	0	0	0
Big Mallard above Jack Cr.	14,123	12.2	0.55	175	1
Big Mallard below Grouse Cr.	19,618	26.1	0.85	432	2.2
Bat Creek	2,957	0.2	0.05	0	0
Lower Big Mallard Cr.	6,672	4.9	0.47	0	0
Big Mallard near mouth	37,070	41.9	0.72	703	1.9
Little Mallard Cr.	8,215	13.3	1.04	76	1

Table 15. Estimated natural and existing cobble embeddedness (%) for streams in the Cove Mallard-Timber Sales areas (NPNF, 1990a).

Stream	Channel Type	Natural	Existing
SF Big Mallard Creek	B	59	59
	C	64	64
Upper Big Mallard Creek	A	48	48
	B	67	68
	C	63	63
Middle Big Mallard Creek	B	53	53
	C	62	62
Noble Creek	A	47	47
	B	67	73
	C	77	83
Lower Big Mallard Creek	B	58	58
	C	70	70
Little Mallard Creek	A	39	39
	B	65	65
	C	72	82
Jersey Creek	A	64	66
	B	67	74
Upper Crooked Creek	A	20	53
	B	25	62
	C	25	67
Upper Rhett Creek	A	48	48
	B	67	81
	C	76	88
Jack Creek	B	67	85
	C	77	85
Grouse Creek	B	67	72
Bat Creek	A	64	72

Stream	Channel Type	Natural	Existing
	B	67	74
	C	77	88
Big Blowout Creek	A	60	60
	B	67	88
Comstock Creek	A	64	80
	B	67	76

Warren Creek Watershed Habitat Assessments - Payette National Forest

The Warren Creek drainage was assessed by Payette National Forest in 1993 to 1995 (PNF, 1995). A synopsis of that assessment for Warren Creek proper is listed in Table 16. A number of tributaries to Warren Creek were also assessed. Most were identified as having excessive fines (greater than 15% as defined by the Payette National Forest) and a lack of pool and deep pool habitats. Warren Creek itself does not appear to have excessive fine sediments, although some reaches are marginal (near 15%), but Warren Creek has significant habitat degradation due to past dredge mining. Warren Creek above Schissler Creek has been extensively dredge mined in the 1920s and 1930s resulting in large, unvegetated cobble/rubble piles throughout the valley. Reach #1 apparently had a temperature measurement greater than the 22^{o}C maximum for cold water biota. Reach #1 is at the confluence with the Salmon River and temperatures may reflect mixing with the Salmon River or the higher air temperatures experienced at lower elevations. These data are considered minor criteria exceedances and insufficient to place the entire creek in violation of temperature standards.

Table 16. Warren Creek Habitat Assessment (PNF, 1995).

Reach	Beginning Confluence	Channel radient	Dominant substrate	Flow (cfs)	Temp. (C)	Salmonids	Comments
1	mouth/ Salmon R.	A - 6%	boulder/ cobble	23	18-24	juv. steelhead & chinook, brook	whitefish, sculpin, sucker at mouth
2	Richardson	A - 9%	boulder/ cobble	14.5	18-21	rainbow/steelhead, brook	fines=5.9%, boulders, high gradient riffles, low pool and gravel
3	unnamed	A - 8%	boulder/ cobble	16	9-21	rainbow, steelhead, brook	fines=14.9%, lack of deep pools
4	Schissler	C -0.4%	gravel/ rubble	14	10-14	rainbow, steelhead, brook	fines=8.2%, slight pool shortage
5	unnamed sidechanne l	C -0.5%	gravel/ rubble	11	8-20	juv.steelhead, brook, bull	fines=9.9%, dredge ponds, rubble/cobble pilings, lack cover/ large woody debris

Reach	Beginning Confluence	Channel radient	Dominant substrate	Flow (cfs)	Temp. (C)	Salmonids	Comments
6	Steamboat	C - 1%	gravel/ rubble	7.4	8-15	steelhead, brook	fines=8.9%, deeply entrenched in dredge piles, lack cover/large woody debris
7	Slaughter	B -2.3%	gravel/ rubble	1.6	15	steelhead, brook	fines=15%, deeply entrenched in dredge piles, lack ponds/ cover/ large woody debris
8	Mayflower	A - 9%	cobble/ rubble/ boulders	1.9	10-19	brook	fines=12.4%, rock wall banks, lack pools, migration barrier
9	Webfoot	A - 5%	gravel/ rubble	0.6	9-14	no fish above barrier	fines=14.9%, small pilings, large pools askew from stream

ASSESSMENT DATA GAPS

More information on water temperature and bull trout spawning and rearing are needed for the mouths of Big and Little Mallard Creeks and Warren Creek to determine if there is indeed a water temperature problem here. No information on conditions has been obtained for Carey Creek and Rabbit Creek sub-watersheds, or from any sub-watershed east of Sabe Creek (with the exception of the three streams, Corn, Cramer, and Bear Basin Creeks, assessed through BURP). Most streams east of Sabe Creek (e.g. Chamberlain Creek drainage) are in wilderness area.

POLLUTANT SOURCE INVENTORY

Pollutant sources may occur as point sources, those for which effluent limitations may be required under sections 301(b)(1)(A) and 301(b)(1)(B), or nonpoint sources of pollutants that are not subject to effluent limitations. There are no NPDES permitted point sources within the Salmon-Chamberlain subbasin according to EPA databases.

Nonpoint pollution sources that can affect sediment discharges in the Salmon-Chamberlain subbasin include forest management and forest road and harvest activities, recreational activities, roads, construction, pastures and paddocks associated with human occupied areas, mining, livestock grazing, and natural and induced mass wasting processes.

The Nez Perce National Forest and Payette National Forest conduct forest management activities including road building, timber thinning and harvesting, and fire suppression that may result in increased erosion and sedimentation. According to data from the Nez Perce National Forest (NPNF, 1994), there are about 288 miles of road in the area from Little Salmon River to Sabe Creek (north side of Salmon River). These roads range in type from high standard, aggregate- surfaced travelway to narrow, native-surfaced jeep trails with extreme grades.

Watershed road density in general across the subbasin is less than 1.0 mile/square mile. The exceptions are in the watersheds of Allison, Carey, Fall Creek, and several smaller drainages in the Salmon River north face 5th field HUC combined watershed. For example, the Jersey Creek watershed has a road density around 1.0 mile/square mile. Overall, the road density throughout the subbasin is considered low. Road density may be of concern in the western Wind River drainage, where there are no listed stream segments. The amount of effect (i.e., hydrograph changes, sediment yield changes, etc.) from road density within the subbasin is potentially minimal since most of the area is roadless or under wilderness designation.

There were two on-going activities in the Big Mallard Creek watershed that had the potential to significantly increase sediment: the hauling of harvested timber and improvements on Forest Road 421. These activities, now completed, were not considered to pose significant threat to steelhead habitat (NPNF, 1999a). Jack Creek has been identified as a source of suspended sediment, presumably originating from sloughed banks and overwidened areas caused by overgrazing, roads, and harvest activity (NPNF, 1994).

Dixie has the potential to produce a small, localized increase in storm water discharge to upper Crooked Creek because of the buildings and recreational development activities. Dixie has been extensively subdivided, with 80 private residences ranging from small lots to 40-acre parcels, and several businesses. The town site is located on the 154-acre Crooked Creek Placer patented mine claim, which runs adjacent to 32 miles of Crooked Creek. This reach of the Creek has been dredge mined and both the riparian and instream habitat has been moderately to severely altered. Common activities associated with the town site include: channelization, bridge construction, ford crossings, removal of riparian vegetation, landfills, stock holding corrals, and homesite development.

Recreational activities in the subbasin may contribute to erosion and sedimentation. They include off-road vehicle use, hunting, hiking, camping, horseback riding, bicycling, fishing, scenery and wildlife viewing, and cross-country skiing.

Placer and dredge mining for precious metals is conducted at several locations. Dredged areas near Warren and Dixie are primarily on private ground. Very few mining claims are still active on the north side of the river, either on private land or Forest Service land. There are no known recent impacts to streams from private claims on the north side of the river, but effects from past mining still influence the Crooked Creek watershed (NPNF, 1999a). The Robinson Dike Mine and private real estate development are probable sediment sources contributing to Rhett Creek.

Mining activity in the Dixie mining district has been extensive since 1861. In particular, three mining and exploration projects in upper Crooked Creek could be potential sources of sediment. Of the three projects, two are inactive, and the third, Million Dollar Placer 1 and 2, is not expected to significantly affect sediment yield (NPNF, 1999a). The Million Dollar Placer Project does occur in the floodplain and riparian zone, approximately 33 feet or more from the stream channel. According to the Nez Perce National Forest (NPNF, 1999a), the mine has exposed and not reclaimed a large area of bare soil in the floodplain of upper Crooked Creek. In the event of high water during flooding, the active part of the project within the floodplain may contribute fine sediment, gravel, and cobble materials.

Grazing activities that may contribute to riparian vegetation loss and increased sediment load are relatively few. They include short-term, site-specific grazing of pack and saddle stock and minor domestic livestock grazing that occurs mostly on private land holdings throughout the subbasin. Past grazing still impacts areas within the Big Creek drainage. Lower Big Mallard supports three grazing allottments, two active and one inactive. Grazing has occurred at various levsls since 1946. Within the Big Mallard Creek watershed, there is a 28,830 acre grazing allottment. Riparian function and channel characteristics have been altered at several ranch and residential locations along Jack, Meyers, and Big Mallard Creeks (USFS, 1999).

Mass wasting processes are important sedimentary processes to account for in the subbasin. The combination of easily weathered granitic rocks that yield non-cohesive soils on steep slopes, and warm Pacific air masses flowing through the area that cause rain-on-snow events, can result in significant events. Landslides and debris torrents are naturally-occurring processes. However, forest management activities have been shown to increase their occurrence. Many times, these mass wasting events are triggered by thunderstorms, the freeze-thaw cycle, wildland fires, or more commonly from rain-on-snow events. The effects from prescribed burning are considered to be less than those of uncontrolled wildland fires (USFS, 1999).

POLLUTANT SOURCE DATA GAP

Information on sediment sources in listed streams is limited in extent. The recent NEZSED modeling performed by the Nez Perce National Forest would serve as a starting point for any further more in-depth characterization work necessary for the subbasin. The Nez Perce NEZSED model predicts natural and activity yield for stream segments along the north side of the Salmon River. Other than this preliminary modeling and that performed on the main Salmon River (see Table 12), there is limited sediment-related monitoring or sampling results available.

SUMMARY OF POLLUTION CONTROL EFFORTS

This section describes some past and present pollution control efforts in surface waters in the subbasin. The scope is limited to those efforts that could control sediment, the primary parameter of concern identified in the 1996 э303(d) list.

Past Pollution Control Efforts

A summary of restoration efforts completed within the subbasin by the Nez Perce National Forest between 1993 and 1997 is contained in Appendix 3. Most pertain to roadway improvements and streambank restoration.

The Idaho Forest Practices Act was codified during the mid-1970's to comply with ϶208 of the Clean Water Act. The Forest Practices Water Quality Management Plan identifies the Rules and Regulations Pertaining to the Idaho Forest Practices Act as best management practices (BMPs) to be used during forest practices (e.g., logging) to protect surface water quality.

Present Pollution Control Efforts

Presently, there are not many control efforts being conducted or immediately planned in the mining areas of Warren Creek and Crooked Creek. The Payette National Forest plans to do some trail work and possibly some road maintenance in the Warren Creek drainage in the vicinity of the Burgdorf Junction fire (Zuniga, 2001). Rehabiliation work in the Crooked Creek drainage is of low priority compared to other projects elsewhere in the Nez Perce National Forest (Gerhardt, 2001).

In general, the USFS has an ongoing program to control pollution associated with forest practices. Fire prevention, suppression, and management activities are conducted by the forest service in ways developed to minimize water pollution. Additionally, the Forest Service has entered into a memorandum of understanding with the state and other federal agencies to address non-point source pollution to waterways. The following are excerted from the Idaho Department of Environmental Quality Non-point Source Management Plan (DEQ, 1999):

"The Forest Service, under the Organic Act Of 1897 (16 U.S.C. 551), the Multiple Use Sustained Yield Act of 1960 (16 U.S.C. 528), as amended, and the National Forest Management Act of 1976 (16 U.S.C. 1600), is directed to regulate the occupancy and use of National Forest System Lands. The Clean Water Act, as amended, (33 U.S.C. 1323) directs the Forest Service to meet state, interstate and local substantive as well as procedural requirements respecting control and abatement of pollution in the same manner, and to the same extent as any non-governmental entity.

"Executive Order 12372 (September 17, 1983) directs the Forest Service to make efforts to accommodate and foster intergovernmental partnership by relying on state processes, to the extent feasible for state coordination and review of proposed federal financial assistance and direct federal development.

"The U.S. Forest Service is responsible for the management of over 20.4 million acres of National Forest Service lands in Idaho. These are public lands that form the headwaters of many of Idaho's important river systems. The Forest Service has the statutory authority to regulate, permit and enforce land-use activities on the National Forest System lands that affect water quality.

“As the designated management agency, the Forest Service is responsible for implementing 1) nonpoint source (NPS) pollution control; and 2) the Idaho State Water Quality Standards on National Forest System lands. The basis of the Forest Services's nonpoint source pollution control policy stems from the: National Nonpoint Source Policy (December 12, 1984); Forest Service Nonpoint Strategy (January 29, 1985); and the USDA Nonpoint Source Water Quality Policy (December 5, 1986). The Forest Service's water quality policy is to: 1) promote the improvement, protection, restoration and the maintenance of water quality to support beneficial uses on all national forest service waters; 2) promote and apply approved best management practices to all management activities as the method for control of NPS pollution; 3) comply with established state or national water quality goals; and 4) design monitoring programs for specific activities and practices that may affect or have the potential to affect in-stream beneficial uses on National Forest System lands.

“The Forest Service also coordinates all water quality programs, on National Forest System lands within its jurisdiction, with the local, state and federal agencies, affected public lands users, adjoining land owners, and other affected interests.” (DEQ, 1999; Appendix A-1, pp.5-6)

“ *THE FEDERAL LAND MANAGEMENT AGENCIES AGREE*

1 . That federal agencies will be subject to, and comply with, state requirements in the same manner and to the same extent as any other party to this agreement, or other nongovernmental entity.

2 . To annually, by May 1, develop or update water quality monitoring plans to meet the intent of the Antidegradation Policy and the NPS Water Quality Management Program, and provide to IDHW monitoring results information relative to the feedback loop.

3. To annually provide, to the designated IDHW and IDL offices, by May 1, a general schedule of proposed land-disturbing activities during the forthcoming year. Projects and programs for which the federal agencies specifically request assistance will be identified.

4. To involve the IDWR, IDHW and IDL at the appropriate time in the NEPA process for projects having significant potential to impact beneficial water uses.

5. To incorporate the ten items for Federal Consistency Review Criteria (pages 26-28 of the Idaho Nonpoint Source Management Program) into NEPA documents.

6. To insure that all new and renewed plans, leases, contracts, special use authorizations, easements, right-of-way documents and other agreements involving permitted activity on federal lands, contain provisions for compliance with all water pollution control statutes and regulations (federal and state) under the authority of the Clean Water Act.

7 . To provide in-house training to federal Personnel to increase employee awareness of, and sensitivity to, the importance of maintaining water quality, potential impacts to water quality, applicable state and federal law, and state-of-the-art techniques used to prevent water quality problems.” (DEQ, 1999, Appendix A-1, p.9)

“The Federal Agencies Agree:

1.To comply with the water quality protection provisions of the IFPA Rules and Regulations.

2.To conduct interim internal reviews of best management practices (BMPs) by annually examining a representative sample (target 10%) of timber related projects on lands they administer and prepare written BMP evaluation reports. Summaries of these reports will be provided to IDL and IDHW, for inclusion in the annual Forest Practices Water Quality Management Plan Report.

3.To participate in the statewide Forest Practices Audit Team, provide necessary information for selection of timber sales and provide technical expertise in audit procedure.
4.To develop and implement a variance policy that assures that when a specialized BMP is used, instead of a specific IFPA rule or regulation, that the practice selected protects beneficial uses.
5.To provide technical support to IDL and participate on the forest practice cumulative effects tasks force.
6.To notify IDHW of any suspected occurrences of beneficial use impairment that occur on National Forest System lands and public lands administered by the BLM.
7.To notify IDL of all suspected non-compliance with water quality protection provisions of the IFPA rules and regulations on federally administered lands.
8.To provide technical support, to IDL, in the administration and implementation of the water quality protection provisions of the rules and regulations pertaining to the IFPA on federally administered lands." (DEQ, 1999; Appendix A-2, pp.3-4)

DISCUSSION

The Salmon-Chamberlain subbasin is predominantly federal land, the majority of which is wilderness designation. With very little privately held land, low road densities, and few areas of disturbance, it is safe to characterize the overall subbasin as one of the more pristine in the lower 48 contiguous states. Notwithstanding, seven tributaries and the main stem of the Salmon River have been listed on the 303(d) list. This listing has apparently been done through an administrative process without actual documented violations of the Idaho Water Quality Standards for the designated pollutants of concern. The assessment of 1997 BURP samples and additional data for the listed stream segments in the subbasin indicates that the 303(d) listed streams are all fully supporting their aquatic life uses.

There are two areas of past and present activities, which are of concern. Warren Creek was extensively dredge mined in the past and a large area remains with sparse natural riparian vegetation. Crooked Creek in the vicinity of Dixie was dredged in the past and currently receives some level of perturbation from local residences and roads. An analysis of macroinvertebrate assemblages indicated that Crooked Creek has experienced some impacts from fine sediments (Clark, 2000). Both streams, however, are fully supporting their aquatic life uses. Although these areas are of concern and should receive some oversight to prevent further degradation or to restore habitat if possible, it is not clear that a TMDL is warranted or justified based on aquatic life assessments.

Throughout the subbasin, there are apparent legacy issues related to several areas that have been altered by mining, road construction, and grazing. Logging accounts for a small percentage of the subbasin, about 2% of the non-wilderness/non-roadless area. It is anticipated that the Forest Service, the principle land owner, will continue to monitor and take corrective actions where necessary to maintain water quality within these areas.

RECOMMENDATIONS AND CONCLUSION

According to the Clean Water Act, any stream with sediment pollution exceeding water quality standards is required to have a TMDL prepared. The subbasin assessment is step one of two, where the second step is preparing the load characterization and allocation for waters truely impaired by pollutants.

Available data indicate a minimally impacted subbasin and aquatic life uses are fully supported. **We conclude that state water quality standards for sediment are not being exceeded in the listed water bodies in this subbasin. Therefore, Big Mallard Creek, Little Mallard Creek, Rhett Creek, Crooked Creek, Big Creek, and Jersey Creek, are to be delisted from the next 303(d) list. Warren Creek shall remain on the 303(d) list for habitat alteration.**

The lower portions of Big Mallard Creek, Little Mallard Creek and Warren Creek need to be further investigated for possible spawning and rearing temperature problems. If the mouths of these creeks are not used for salmonid spawning, then this is perhaps a moot point. **Crooked Creek violates temperature criteria for bull trout spawning and rearing. The Crooked Creek TMDL for temperature follows in the next sections of this document.**

The IDEQ will also delist the Salmon River, from Cherry Creek to Corn Creek. There are no pollutants identified for its 303(d) listing. This suggests it may have been listed based on concern that the Salmon River's water quality be preserved for fisheries and recreation, not concern that its water quality has been compromised. There is no evidence establishing that the river violates any state water quality standard. Since no pollution has been documented, and in fact all signs indicate it is one of the more pristine rivers in the country outside Alaska, a TMDL for the Middle Salmon River within the subbasin is not necessary at this time. Since it is important for threatened and endangered salmonids, the river will continue to be monitored and protected by land management agencies into the foreseeable future in accordance with their responsibilities and the Endangered Species Act.

Warren Creek, though impacted by past dredge mining, is still supporting its beneficial uses. Had beneficial uses not been fully supported, it is not possible to perform a load-oriented TMDL for habitat alteration. A recovery plan should be pursued by the Payette National Forest to address the long-term stability of dredged areas. Since impacts from roadways may be the greatest source of current human-caused sedimentation, a water quality management plan directed at road problems should be investigated by the Forest Service. Additionally, the sub-watershed will require substantial stream restoration work to return riparian areas to the natural state. We believe this restoration is important to further protect the aquatic life uses in this creek.

Load Allocation
For
Total Maximum Daily Load (TMDL)

Crooked Creek
Middle Salmon River – Chamberlain Creek Subbasin
17060207

Revised: December 2002

<u>WQ CONCERNS AT A GLANCE:</u>

Water Body of Concern:	**Crooked Creek**
Assessment Units:	**(ID17060207SL067_05, ID17060207SL068_02, ID17060207SL068_03, ID17060207SL068_04)**
Subbasin:	**Middle Salmon River-Chamberlain Creek**
Watershed Identifier:	**17060207**
Parameter of Concern:	**Temperature**
Key Resources:	**Chinook Salmon** **Steelhead Trout** **Bull Trout** **Westslope Cutthroat Trout** **Resident Rainbow Trout**
Uses Affected:	**Salmonid Spawning, Cold Water Biota**
Sources Considered:	**Legacy Effects from Historic Mining,** **Altered Riparian Condition**

WATERSHED DESCRIPTION

Crooked Creek is a tributary to the main Salmon River in central Idaho. Crooked Creek originates near the divide with the South Fork Red River (South Fork Clearwater River subbasin) below Elk City. The creek flows southwest for about 11 miles, then bends west for several miles, then flows southwest again for another eight miles before entering the Salmon River. Fifty-four percent of the Crooked Creek watershed is in the Gospel-Hump Wilderness (the lower half of the stream), while 2% is in private ownership. The remaining lands are in the Nez Perce National Forest. There are two large tributaries, Big Creek and Lake Creek, entering the middle reaches of Crooked Creek as well as numerous smaller tributaries throughout the watershed. The upper half of Crooked Creek is in mixed conifer forest communities. Below Big Creek, Crooked Creek enters an area of decreasing tree density. By the time Crooked Creek reaches the Salmon River, the landscape is predominantly grass/shrub communities with few trees (see aerial photographs in Appendix 6 for examples).

WATER QUALITY CONCERNS

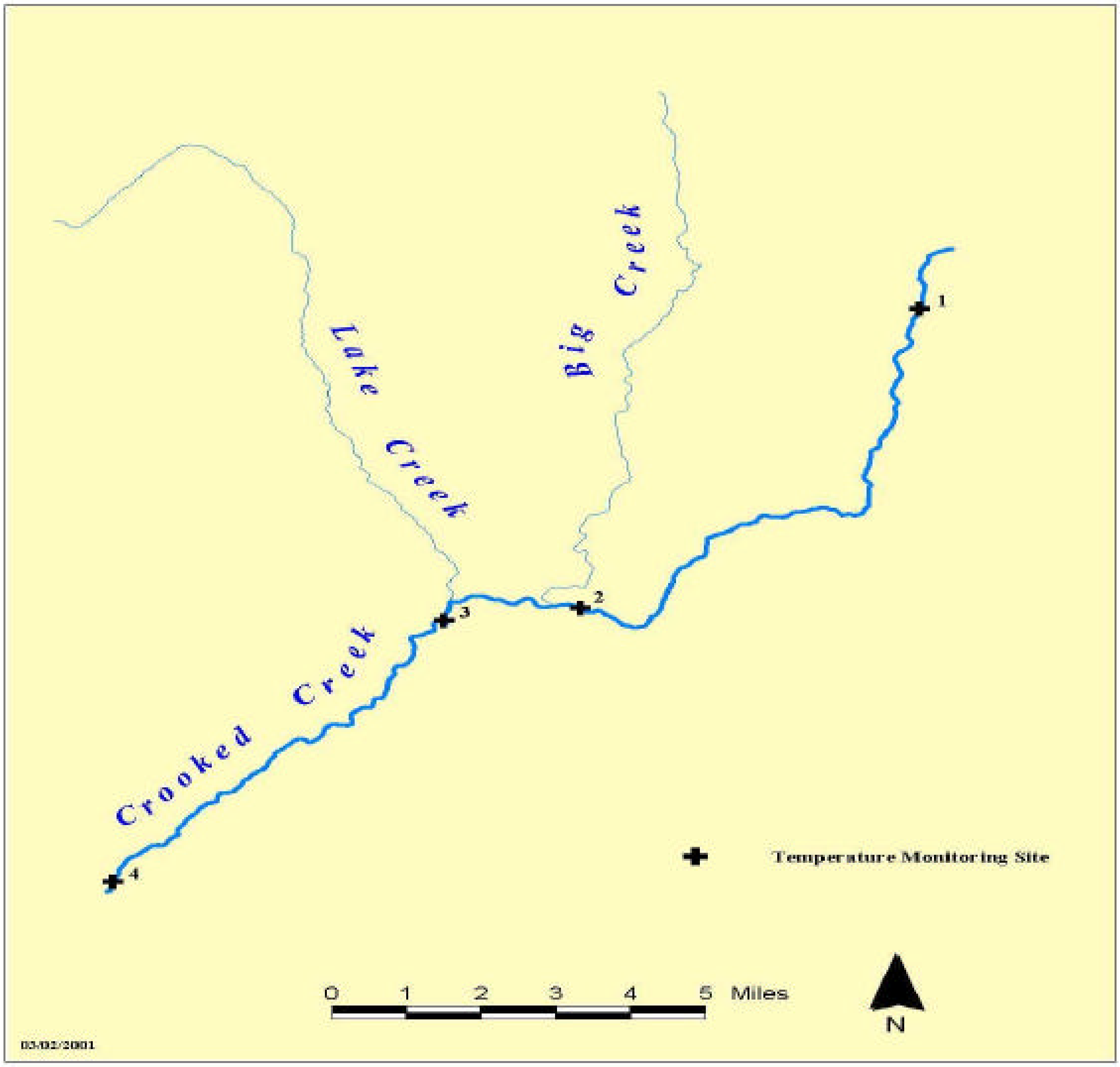
The problem assessment process determined that, although moderately high, sediment was not impairing aquatic life in this stream. However, it was determined that temperature measurements were high enough that salmonid spawning in upper Crooked Creek and bull trout spawning and rearing, if they occur in Crooked Creek, may be affected.

Temperature loggers have been placed in Crooked Creek at four locations every year from 1994 to 1999 (Map 12). These four locations include: 1) a headwaters site (Site 1), 2) a location below the town of Dixie and the Forest Service Dixie Work Center, but above the tributaries of Big Creek and Lake Creek (Site 2), 3) a location directly below Lake and Big Creeks (Site 3), and 4) a fourth location near the mouth of Crooked Creek (Site 4). The monitoring data show that the headwaters are relatively cool, but the water temperature increases rapidly through the impacted areas around Dixie. Water temperatures are cooled by entering the wilderness area and from the flow from Big Creek and Lake Creek. The water heats up again as it travels the remaining distance through the wilderness area to the mouth.

Elevations range from near 6000 feet in the headwaters to near 2000 feet at the mouth. We presumed that heating of the water as it passes through the wilderness area is a natural phenomenon, a result of atmospheric influences (air temperature and direct solar radiation). Aerial photos reveal that much of the wilderness area is open woodlands and grasslands (see Appendix 6).

Air temperature data for the Dixie area are presented in Appendix 5. From 1960 to 1990, Dixie reached an average maximum air temperature of about 78°F (25.5°C) in the summer time. With a standard lapse rate of 3.6°F (2°C) increase for every drop in 1000 feet of elevation (Aherns 1991), the mouth of Crooked Creek 3000 feet down may normally experience average maximum air temperatures near 89°F (31.7°C).

Map 12. Temperature monitoring sites on Crooked Creek.



A description of the location of the four sites follows:

- Site 1, approximately 5860 feet elevation, is located in the headwaters above Horse Flat Creek, which is 1.5 miles downstream from the origin of Crooked Creek at Dixie Summit.
- Site 2, approximately 5020 feet elevation, is 1.5 miles upstream of Big Creek and above the wilderness boundary. It is below the town of Dixie and a large open meadow with airstrip.
- Site 3, approximately 4240 feet elevation, is approximately 300 feet below Lake Creek tributary.
- Site 4, approximately 2100 feet elevation, is 0.25 miles upstream from the mouth of Crooked Creek.

Temperature Data Analysis

Surface water temperature data collected by the Nez Perce National Forest from Crooked Creek during 1994 to 1999 were used in this assessment. The data were collected from the four localities using temperature data loggers set to record hourly values. Raw data files were edited by deleting spurious air temperature values, days with less than 24 readings, and negative values. Mean and maximum statistics were calculated from the edited raw data and are presented in Table 17.

Table 17. Overall mean, peak maximum weekly maximum temperature (MWMT), and peak maximum weekly average temperature (MWAT) statistics calculated for the recording period (late June to early October) for each site and year.

Overall Mean Temperature ^{o}C				
Year	Site 1	Site 2	Site 3	Site 4
1994	8.7	11.3	11.1	14.3*
1995	7.4	10.1	9.0	12.3
1996	8.5	11.2	10.3	12.4
1997	7.6	8.9#	8.8	13.5
1998	10.0*	12.4*	12.1*	12.1
1999	5.6#	9.4	7.9#	10.3#
Average	8.0	10.6	9.7	12.5
Highest Maximum Weekly Maximum Temperature ^{o}C (MWMT)				
1994	14.1	21.5*	18.2*	22.4*
1995	12.7#	18.6#	15.3#	18.9
1996	13.5	19.5	15.6	18.8#
1997	12.9	17.2	15.6	19.1
1998	14.4*	20.2	17.0	20.9
1999	12.7#	18.7	15.4	19.6
Average	13.4	19.3	16.2	20.0
Highest Maximum Weekly Average Temperature ^{o}C (MWAT)				
1994	13.0*	16.7*	16.0*	19.5*
1995	10.7#	13.8#	13.2#	16.3#
1996	12.0	14.9	13.7	16.7
1997	11.5	14.1	13.9	16.9
1998	12.3	15.5	14.9	18.2
1999	11.6	14.3	13.7	17.0
Average	11.9	14.9	14.2	17.4

* Highest temperature for each statistic recorded at that site.
# Lowest temperature for each statistic recorded at that site.

Peak MWAT demonstrate consistently that 1994 was one of the warmest years and 1995 was one of the coolest in this data set. The other two statistics show this relationship less consistently. Overall means vary only a few degrees from upstream (Site 1) to downstream (Site 4). However, the average overall mean demonstrates an increase in temperature at Site 2 followed by a decrease in temperature at Site 3. This decrease in temperature at Site 3 is consistent throughout the data set. These data suggest that even the headwaters of Crooked Creek (Site 1) are fairly warm in the summer with peak MWMT averaging at 13.4°C.

Temperature criteria evaluation

Edited data sets were compared to Idaho temperature criteria for cold water aquatic life (22°C instantaneous and 19°C daily average throughout the monitoring periods), bull trout spawning (13°C instantaneous and 9°C daily average September through October at elevations over 4593 feet), bull trout juvenile rearing (12°C daily average June through August), and salmonid spawning (13°C instantaneous and 9°C daily average January 15 through July 15 and September through October). The edited data sets were also compared to the federal bull trout temperature criterion (10°C MWMT June through September). The number of days exceeding these criteria are summarized in Table 18 for each site and each year.

Table 18. Number of days exceeding temperature criteria at four sites on Crooked Creek.

Number of days in 1994 that Crooked Creek temperatures violated criteria.							
SITE	**22C[1]**	**19C[2]**	**13C[3]**	**12C[4]**	**10C[5]**	**9C-SS[6]**	**9C-BT[7]**
Site 1 Horse Flat Creek	0	0	0	15	65	15	1
Site 2 Halfway House	4	0	28	49	89	31	14
Site 3 Lake Creek	0	0	15	0	77	30	0
Site 4 Mouth	7	11	36	0	81	44	0
TOTAL # of Days	11	11	79	64	312	120	15

Number of days in 1995 that Crooked Creek temperatures violated criteria.							
SITE	**22C**	**19C**	**13C**	**12C**	**10C**	**9C-SS**	**9C-BT**
Site 1 Horse Flat Creek	0	0	1	0	62	18	6
Site 2 Halfway House	0	0	31	33	87	39	20
Site 3 Lake Creek	0	0	9	0	81	33	0
Site 4 Mouth	0	0	25	0	76	34	0
TOTAL # of Days	0	0	66	33	306	124	26

Number of days in 1996 that Crooked Creek temperatures violated criteria.							
SITE	**22C**	**19C**	**13C**	**12C**	**10C**	**9C-SS**	**9C-BT**
Site 1 Horse Flat Creek	0	0	0	3	46	3	2
Site 2 Halfway House	0	0	22	46	72	26	13
Site 3 Lake Creek	0	0	7	0	71	22	0
Site 4 Mouth	0	0	17	0	69	40	0
TOTAL # of Days	0	0	46	49	258	91	15

1 22C=cold water aquatic life maximum year round.
2 19C=cold water aquatic life daily average year round.
3 13C=salmonid spawning maximum to 7/15 and 9/15-11/15.
4 12C=bull trout daily average 6/1-8/31.
5 10C=bull trout maximum weekly maximum 6/1-9/30.
6 9C-SS=salmonid spawning daily average to 7/15 and 9/15-11/15.
7 9C-BT=bull trout spawning 9/1-10/31.

Table 18. Continued.

Number of days in 1997 that Crooked Creek temperatures violated criteria.							
SITE	**22C**	**19C**	**13C**	**12C**	**10C**	**9C-SS**	**9C-BT**
Site 1 Horse Flat Creek	0	0	0	1	45	11	11
Site 2 Halfway House	0	0	11	32	60	16	16
Site 3 Lake Creek	0	0	6	0	49	17	0
Site 4 Mouth	0	0	27	0	75	38	0
TOTAL # of Days	0	0	44	33	229	82	27

Number of days in 1998 that Crooked Creek temperatures violated criteria.							
SITE	**22C**	**19C**	**13C**	**12C**	**10C**	**9C-SS**	**9C-BT**
Site 1 Horse Flat Creek	0	0	2	16	62	20	18
Site 2 Halfway House	0	0	19	48	73	22	20
Site 3 Lake Creek	0	0	15	0	66	21	0
Site 4 Mouth	0	0	47	0	118	71	0
TOTAL # of Days	0	0	83	64	319	134	38

Number of days in 1999 that Crooked Creek temperatures violated criteria.							
SITE	**22C**	**19C**	**13C**	**12C**	**10C**	**9C-SS**	**9C-BT**
Site 1 Horse Flat Creek	0	0	2	1	62	8	0
Site 2 Halfway House	0	0	11	45	75	18	10
Site 3 Lake Creek	0	0	4	0	60	12	0
Site 4 Mouth	0	0	34	0	108	60	0
TOTAL # of Days	0	0	51	46	305	98	10

Average annual number of days that Crooked Creek temperatures violated criteria at each site.							
SITE	**22C**	**19C**	**13C**	**12C**	**10C**	**9C-SS**	**9C-BT**
Site 1 Horse Flat Creek	0	0	0.83	6	57	12.5	6.33
Site 2 Halfway House	0.67	0	20.33	42.17	76	25.33	15.5
Site 3 Lake Creek	0	0	9.33	0	67.33	22.5	0
Site 4 Mouth	1.17	1.83	31	0	87.83	47.83	0
TOTAL # of Days	1.84	1.83	61.49	48.17	288.16	108.16	21.83

Cold water aquatic life criteria (22C and 19C) were exceeded in only one (1994) of the six years of data. All other criteria were exceeded every year. The daily maximum salmonid spawning criterion (13C) included both spring spawning and fall spawning time periods. This criterion at Site 1 was exceeded only occasionally. At the other sites it was exceeded up to a month or more. The 12C and 9C-BT are state criteria for bull trout rearing and spawning, respectively. These criteria are applied to waters above 4593 ft. (1400 m) elevation. Thus, no violations are recorded for Sites 3 and 4 for these criteria. The 12C criterion is exceeded from zero to 16 days, with an average of six days at Site 1. At Site 2 this criterion is exceeded an average of 42 days. The 9C-SS and 9C-BT criteria reflect the differences between just the fall spawning period (9C-BT) and both spring and fall spawning periods (9C-SS). At Sites 1 and 2 the number of days exceeding criteria can double when both spring and fall spawning periods are considered. The 9C-SS criterion shows how spring and fall spawning temperatures faired at Sites 3 and 4, generally a month or more of violations. The 10C criterion is the federal bull trout criterion that applies to the entire creek during the summer months (June through September). It is the lowest temperature of all the criteria represented here that applies during the warmest time period of the year. Therefore, the 10C criterion reflects the maximum number of days in violation, averaging from 57 days at Site 1 to 88 days at Site 4.

The elevation change between Site 1 and Site 4 is about 3,731 feet. Over half (56%) of that change occurs between Sites 3 and 4 (Table 19). Surface waters tend to warm to a greater extent at lower elevations because air temperature is usually greater. However, the rate of change in water temperature should be proportional to the change in elevation, regardless of actual elevation provided that the water is flowing at the same rate and exposure is the same. Crooked Creek, however, has two large tributaries (Big Creek and Lake Creek) between Sites 2 and 3 that potentially contribute cooling water to Crooked Creek. And the gradient in the upper section is much lower than below Site 2.

Table 19. Amount of change between sites for numbers of days exceeding certain criteria (averages for period of record: 1994 to 1999).

Site	Elevation (feet)	Distance from Source (miles)	No. Days Exceeding 9^oC*	No. Days Exceeding 10^oC@
#1 – Horse Flat Creek	5860	1.5	13	57
#2 – Halfway House CG	5049	10.7	25	76
Change from #1 to #2	-811(22%)	+9.2(47%)	+12(34%)	+19(61%)
#3 – Lake Creek	4209	12.8	23	67
Change from #2 to #3	-840(22%)	+2.1(11%)	-2(-6%)	-9(-29%)
#4 – Mouth	2129	21	48	88
Change from #3 to #4	-2080(56%)	+8.2(42%)	+25(71%)	+21(68%)

*9^oC as a daily average first day of monitoring through 7/15 and 9/1 through 10/31.
@ 10^oC as a 7-day moving average of daily maximums during June 1 to September 30.

Table 19 shows rates of change for various parameters between sites. For example, the elevation change between Sites 1 and 2 is 811 feet or 22% of the total elevation change for the creek. The largest elevation change occurs between Sites 3 and 4 (56%). The distance traveled between sites is greatest between Sites 1 and 2 (9.2 miles). We have used two criteria in Table 19 to analyze rates of change in number of days exceeding criteria. We used number of days exceeding criteria as an indication of water temperature; in other words, cooler temperatures produce few numbers of days exceeding criteria, warmer temperatures produce more days exceeding criteria. The number of days exceeding a daily average of 9^oC is based on the salmonid spawning criteria that would normally apply to Crooked Creek in the spring to July 15 for rainbow and cutthroat trout and from September 1 to October 31 for bull trout. Table 19 shows the number of days exceeding 9^oC as a daily average during those time periods. The other criterion is the federal bull trout criterion of 10^oC as a 7-day moving average of the daily maximums. This criterion applies June 1 through September 30.

The 10^oC criterion shows that there was about an equal amount of change in number of exceeding days between Sites 1 and 2 (19 days) as compared to Sites 3 and 4 (21 days) despite a two-fold difference in elevation change under the same comparison (811 ft. versus 2080 ft.). This suggests that the creek between Sites 1 and 2 is warming more than it should based on elevation change alone. The 9°C criterion does not show this relationship. However, this criterion was not applied during the warmest part of the summer between July 15 and September 1. In this case, the change in number of days exceeding 9°C daily average between Sites 3 and 4 is about twice the rate of change between Sites 1 and 2, consistent with elevation differences. In avoiding the warmest part of summer, this criterion does not reflect exceedances during warmer air temperatures and perhaps direct solar inputs from the sun high in the sky.

Rates of Temperature Increase

Rates of warming were estimated from raw temperature data as well. The differences in overall recording period mean temperature, maximum weekly maximum, and maximum weekly average, each averaged for all years of data, were calculated for the stream reaches between monitoring Sites 1 and 2, 2 and 3, and 3 and 4. For example, an overall mean is calculated for the June to October recording period for each site for each year. The overall means for each year are then averaged to form a single overall mean for that site. To determine rates of change between two sites, the overall mean for the upper site is subtracted from the overall mean for the lower site. These differences were divided by the amount of change in elevation and reach length to obtain two rates of temperature change. These rates are temperature change per stream mile and temperature change per 1000 feet of elevation (Table 20).

Table 20. Temperature change as a function of stream miles and elevation.

Site 1 to Site 2: 9.2 stream miles, 811 feet drop in elevation, gradient = 88.3ft/mi.		
	Rate of change per stream mile	Rate of change per 1000 feet elevation
Change in overall mean	0.28°C	3.2°C
Change in highest MWMT*	0.64°C	7.3°C
Change in highest MWAT	0.33°C	3.7°C
Site 2 to Site 3: 2.1 stream miles, 840 feet drop in elevation, gradient = 394.4 ft/mi.		
	Rate of change per stream mile	Rate of change per 1000 feet elevation
Change in overall mean	-0.41°C	-1.0°C
Change in highest MWMT	-1.46°C	-3.7°C
Change in highest MWAT	-0.31°C	-0.8°C
Site 3 to Site 4: 8.2 stream miles, 2080 feet drop in elevation, gradient = 252.4 ft/mi.		
	Rate of change per stream mile	Rate of change per 1000 feet elevation
Change in overall mean	0.34°C	1.3°C
Change in highest MWMT	0.46°C	1.8°C
Change in highest MWAT	0.39°C	1.5°C

*MWMT = maximum weekly average of daily maximum water temperatures.
MWAT = maximum weekly average of daily average water temperatures.

Crooked Creek cools between Sites 2 and 3 because Big Creek and Lake Creek add flow, the stream turns westward and may receive more shading from the mountain ridge to its south, and there is an increase of riparian cover in the wilderness area. Thus rates of change are negative values. Between Sites 1 and 2 the gradient is the lowest (88.3 ft/mi or 1.7%) although this stretch is the longest distance (9.2 miles). Residence time is greatest between Sites 1 and 2. Between Sites 3 and 4 the distance (8.2 miles) is similar to Sites 1 and 2, however, the gradient is substantially greater (252.4 ft/mi or 4.8%). The rates of change per stream mile are similar between the lower reaches and the upper reaches. The rates of change per 1000 ft. elevation between Sites 1 and 2 are at least twice the rates of change between Sites 3 and 4.

The stream reach between monitoring Sites 1 and 2 had the highest rate of temperature increase on an elevational basis. This reach also has the lowest gradient, slower residence time, and contains the most human disturbance, particularly the Dixie mining district, the town of Dixie, the airstrip near Dixie Work Center, and associated roads. The stream reach between monitoring Sites 3 and 4 is contained primarily in the Gospel Hump Wilderness. An area that was affected by some legacy human disturbance from grazing (and possibly mining) at one time, and presumably some disturbance from wildfire and current recreational activities. However, the rate of temperature increase between Sites 1 and 2 needs to be reduced to be comparable to the stream reaches between Sites 3 and 4.

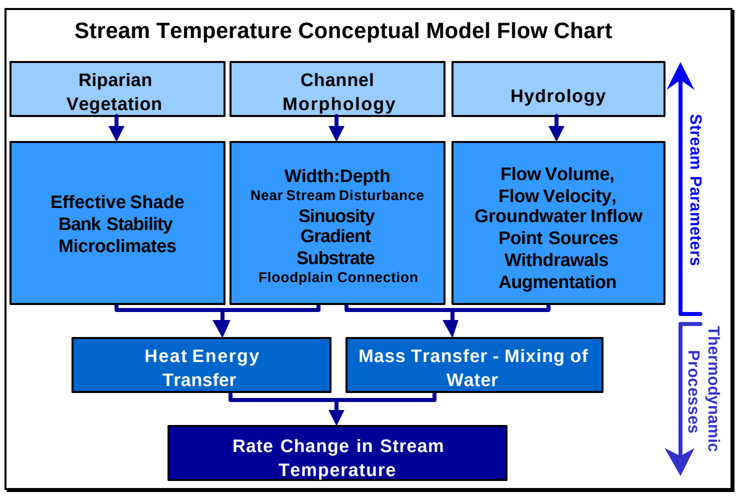
Temperature Summary

Temperature data suggest (see Table 18) that Crooked Creek may have slightly elevated temperatures naturally. The mouth of Crooked Creek on average has slight exceedances of cold water aquatic life criteria, consistent probably with the Salmon River itself in this canyon. Even in the headwaters of Crooked Creek stream temperatures are slightly greater than criteria on average creating a few days where salmonid spawning criteria are exceeded. Because salmonid spawning criteria are applied to a default time period for spring and fall spawning species, individual streams may have warmer temperatures near the end of the spring spawning period (mid-July) or at the beginning of the fall spawning period (September 1st) without seriously harming the actual spawning in the stream (i.e. fish spawn when the temperature is right and there is sufficient time to do so). Additionally, because we often consider average condition, there will be hot years when criteria are exceeded more often, and there will be cold years when criteria may not be exceed at all. In order to avoid confusion about criteria exceedances, the goal of this TMDL is to achieve the natural temperature regime in the stream by returning the effective shade to its natural condition. We anticipate that the natural temperature regime is cooler than the present condition, however, the natural temperature regime may not necessarily exclude temperature criteria exceedances.

Temperature TMDL – Effective Shade/Thermal Load Modeling

Effective Shade Overview - Description of Shading Processes
(Provided by Peter Leinenbach, USEPA)

At any particular instant of time, a defined stream reach is capable of sustaining a particular water column temperature. Stream temperature change that results within a defined reach is explained rather simply. The temperature of a parcel of water traversing a stream/river reach enters the reach with a given temperature. If that temperature is greater than the energy balance is capable of supporting, the temperature will decrease. If that temperature is less than energy balance is capable of supporting, the temperature will increase. Stream temperature change within a defined reach, is induced by the energy balance between the parcel of water and the surrounding environment and transport of the parcel through the reach. The general relationships between stream parameters, thermodynamic processes (heat and mass transfer) and stream temperature change are outlined in the flow chart below.



Cumulative Effects

It takes time for the water parcel to traverse the longitudinal distance of the defined reach, during which the energy processes drive stream temperature change. At any particular instant of time, water that enters the upstream portion of the reach is never exactly the temperature that is supported by the defined reach. And, as the water is transferred downstream, heat energy and hydraulic processes that are variable with time and space interact with the water parcel and induce water temperature change. Further, heat energy is stored within this parcel of water and its temperature is the result of the heat energy processes upstream. This is commonly referred to as a cumulative temperature effect, where conditions at a site contribute to heating of an already heated parcel of stream water. The described scenario is a simplification; however, understanding the basic processes in which stream temperature change occurs over the course of a defined reach and period of time is essential.

Thermal Role of Riparian Vegetation

The role of near stream land cover in maintaining a healthy stream condition and water quality is well documented and accepted in scientific literature (Beschta et al. 1987). Riparian vegetation plays an important role in controlling stream temperature change. The important impacts that near stream land cover has upon the stream and the surrounding environment warrant listing.

- Near stream vegetation height, width and density combine to produce shadows that when cast across the stream reduce solar radiant loading.
- Near stream land cover creates a thermal microclimate that generally maintains cooler air temperatures, higher relative humidity and lower wind speeds along stream corridors.
- Bank stability is largely a function of near stream vegetation. Specifically, channel morphology is often highly influenced by land cover type and condition by affecting floodplain and instream roughness, contributing coarse woody debris and influencing sedimentation, stream substrate composition and stream bank stability.

The warming of water temperature as a stream travels and drops in elevation (longitudinal heating) is a natural process. However, rates of heating can be dramatically reduced when high levels of shade exist and solar radiation loading is minimized. The overriding justification for a reduction in solar radiation loading is to minimize longitudinal heating. A limiting factor in reducing longitudinal stream heating is that there is a natural maximum level of shade that a given stream is capable of attaining.

Stream Surface Shade - Defined

Stream surface shade is an important parameter that controls the stream heating derived from solar radiation. Solar radiation has the potential to be the largest heat transfer mechanism in a stream system. Human activities can degrade near stream land cover and/or channel morphology, and in turn, decrease shade. It follows that human caused reductions in stream surface shade have the potential to cause significant increases in heat delivery to a stream system. Stream shade levels can also serve as an indicator of near stream land cover and channel morphology condition. For these reasons, stream shade is a focus of this analytical effort.

Shade is the amount of solar energy that is obscured or reflected by vegetation or topography above a stream. Shade is expressed in units of energy per unit area per unit time, or as a percent of total possible energy. In contrast, canopy cover is the percent of the sky covered by vegetation or topography. Shade producing features will cast a shadow on the water while canopy cover may not. In order to assess the ability of riparian land cover to shield a stream from solar radiation, two basic characteristics of shade must be addressed: *shade duration* and *shade quality.* The length of time that a stream receives shade can be referred to as *shade duration*. The density of shade that affects the amount of radiation blocked by the shade producing features is referred to as *shade quality.* Effective shade (**Figure 1**) is amount of potential solar radiation not reaching the stream surface and is a function of *shade duration* and *shade quality.*

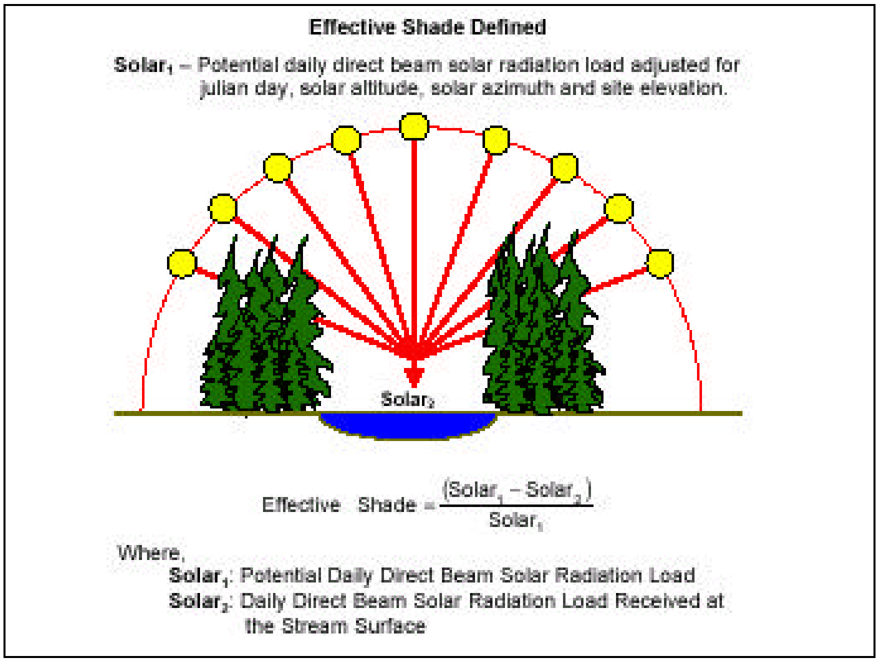


Figure 1. Definition of Effective Shade

In the Northern Hemisphere, the earth tilts on its axis toward the sun during summertime months allowing longer day length and higher solar altitude, both of which are functions of solar declination (i.e., a measure of the earth's tilt toward the sun) (**Figure 2**). Geographic position (i.e., latitude and longitude) fixes the stream to a position on the globe, while aspect provides the stream/riparian orientation. Near stream land cover height, width and density describe the physical barriers between the stream and sun that can attenuate and scatter incoming solar radiation (i.e., produce shade) (**Table 21**). The solar position has a vertical component (i.e., solar altitude) and a horizontal component (i.e., solar azimuth) that are both functions of time/date (i.e., solar declination) and the earth's rotation (i.e., hour angle measured as 15^{o} per hour). While the interaction of these shade variables may seem complex, the mathematics that describes them is relatively straightforward geometry. Using solar tables or mathematical simulations, the potential daily solar load can be quantified. The measured solar load at the stream surface can easily be measured with a Solar Pathfinder© or estimated using mathematical shade simulation computer programs (Boyd, 1996 and Park, 1993).

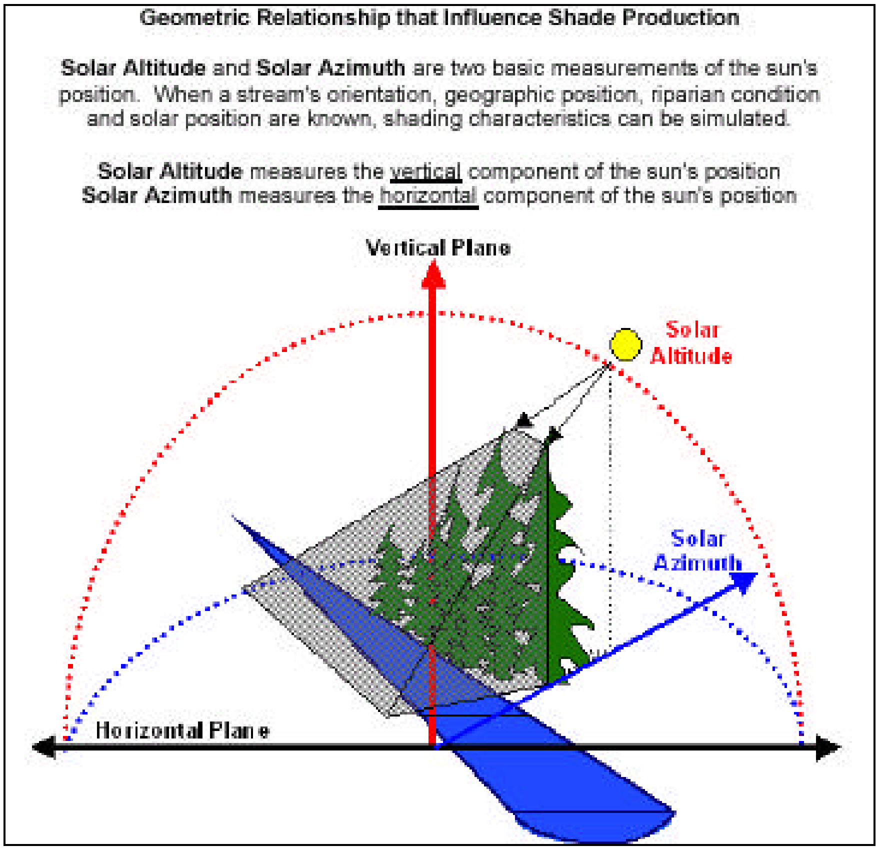


Figure 2. Parameters that Affect Shade and Geometric Relationships

Table 21. Factors that influence stream shade.

Description	Parameter
Season/Time	Date/Time
Stream Characteristics	Aspect, **Channel Width**
Geographic Position	Latitude, Longitude
Vegetative Characteristics	**Near Stream Land Cover Height, Width, and Density**
Solar Position	Solar Altitude, Solar Azimuth

bold type indicates factors that are influenced by human activities

System Potential Effective Shade - Defined

Primary factors that affect shade are near stream vegetation height and channel width (i.e. bankfull width). The maximum level of shade practical at a particular site is termed the "system potential" effective shade level. System Potential Effective Shade occurs when:

1. Near stream vegetation is at a mature life stage
   - Vegetation community is mature and undisturbed from anthropogenic sources;
   - Vegetation height and density is at or near the potential expected for the given plant community;
   - Vegetation is sufficiently wide to maximize solar attenuation; and
   - Vegetation width accommodates channel migrations.

2. Channel width reflects a suitable range for hydrologic process given that near stream vegetation is at a mature life stage
   - Stream banks reflect appropriate ranges of stability via vegetation rooting strength and floodplain roughness;
   - Sedimentation reflects appropriate levels of sediment input and transport;
   - Substrate is appropriate to channel type; and
   - Local high flow shear velocities are within appropriate ranges based on watershed hydrology and climate.

System Potential Land Cover

As listed above, "System potential land cover" is necessary to achieve "system potential effective shade," and is defined for purposes of the TMDL as "the potential near stream land cover condition that can grow and reproduce on a site, given: climate, elevation, soil properties, plant biology and hydrologic processes." System potential does not consider management or land use as limiting factors. In essence, system potential is the design condition used for TMDL analysis that meets the temperature standard by minimizing human related warming.

System potential is an estimate of the condition where anthropogenic activities that cause stream warming are minimized.

System potential is not an estimate of pre-settlement conditions. Although it is helpful to consider historic land cover patterns, channel conditions and hydrology, many areas have been altered to the point that the historic condition is no longer attainable given drastic changes in stream location and hydrology (channel armoring, wetland draining, urbanization, etc.).

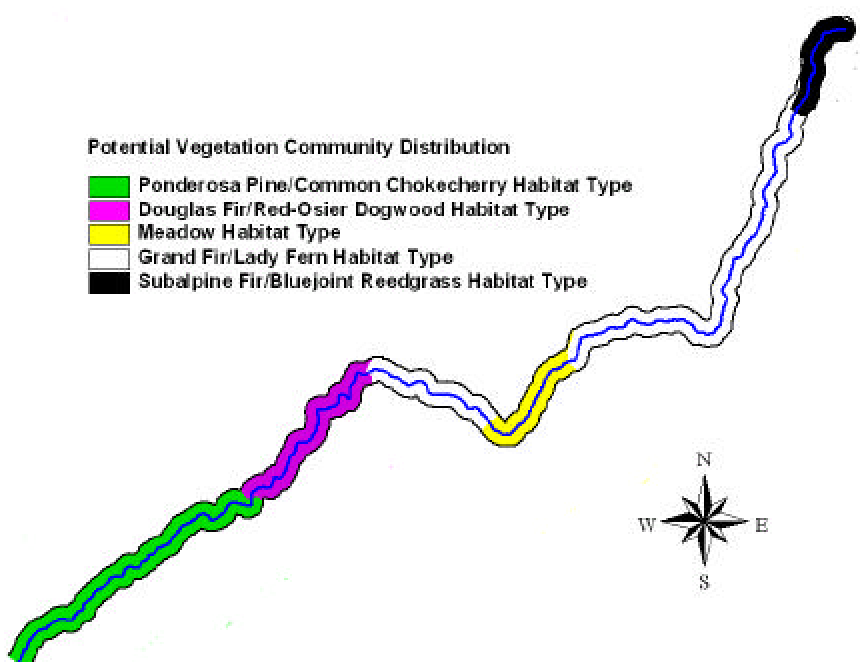
Potential Natural Vegetation

Spatial Distribution of Potential Natural Vegetation

Potential natural vegetation cover was estimated from habitat type descriptions provided by Hansen et al. (1995). We determined the riparian habitat types from Hansen et al. (1995) most likely to apply to Crooked Creek. Estimated habitat type conditions were intended to provide general representations of expected natural vegetation conditions throughout Crooked Creek. Estimated habitat types are not necessarily representative of ***current*** conditions around Crooked Creek.

The upper reaches (from Horse Flat Creek to Lake Creek, but not including the large meadow) were included in the grand fir/lady fern (*Abies grandis/Athyrium filix-femina*) habitat type. The very headwaters (above Horse Flat Creek) may be in more of a subalpine fir habitat type. Hansen et al. (1995) included a subalpine fir/bluejoint reedgrass (*Abies lasiocarpus/ Calamagrostis canadensis*) habitat type that may be representative. The large, grassy meadow near Dixie Work Center and airstrip was included in the Coyote willow (*Salix exigua var. exigua*) or tufted hairgrass (*Deschampsia cespitosa*) habitat type depending on whether or not the meadow was once willow dominated or grass dominated. The lower reaches (below Lake Creek) are either in the Douglas fir/red-osier dogwood (*Psuedotsuga menziesii/Cornus stolonifera*) habitat type or the ponderosa pine/common chokecherry (*Pinus ponderosa/ Prunus virginiana*) habitat type. **Figure 3** illustrates the spatial distribution of these vegetation communities along Crooked Creek.

Figure 3. Distribution of Potential Natural Vegetation Communities along Crooked Creek



Canopy Cover of Potential Natural Vegetation

For each habitat type, Hansen et al. (1995) provided average canopy cover, the range of canopy covers, and the constancy (% of sampling sites that contained the species) for species recorded in sampling plots. A weighted average canopy cover was calculated for each of the habitat types by summing the product of the average canopy cover and constancy for each tree species within each habitat type group. These calculations are presented in **Table 22**. It is important to note that these calculated cover values represent expected conditions based on the Habitat Type conditions presented above. These calculated canopy cover values should be viewed as a general representation of expected conditions within these habitat type groups. It must also be noted that, the Crooked Creek riparian area may contain other species not represented in this Table.

Table 22. A summary of species, canopy cover, and constancy for Habitat Types along Crooked Creek (from Hansen et al. (1995))

Grand Fir/Lady Fern Habitat Type	
Grand fir (*Abies grandis*)	30% average cover (100% constancy) = 30
Subalpine fir (*Abies lasiocarpus*)	3% average cover (20% constancy) = 0.6
Paper Birch (*Betula Papyrifera*)	3% average cover (20% constancy) = 0.6
Western Larch (*Larix Occidentalis*)	12% average cover (40% constancy) = 5
Spruce (*Picea spp.*)	20% average cover (60% constancy) = 12
Black Cottonwood (*Popuus trichocarpa*)	2% average cover (40% constancy) = 0.8
Douglas fir (*Psuedotsuga menziesii*)	9% average cover (60% constancy) = 5
Rocky mountain maple (*Acer glabrum*)	13% average cover (100% constancy) = 13
Mountain Alder (*Alnus incana*)	22% average cover (40% constancy) = 9
	Total weighted average cover = 76%
Subalpine Fir/Bluejoint Reedgrass Habitat Type	
Subalpine fir (*Abies lasiocarpus*)	32% average cover (100% constancy) = 32
Spruce (*Picea spp.*)	38% average cover (100% constancy) = 38
Whitebark Pine (*Pinus albicaulis*)	1% average cover (20% constancy) = 0.2
Lodgepole Pine (*Pinus contorta*)	17% average cover (50% constancy) = 9
Mountain Alder (*Alnus incana*)	2% average cover (20% constancy) = 0.4
	Total weighted average cover = 80%
Meadow Habitat Type	
Current	
Tufted hairgrass (*Deschampsia cespitosa*)	42% average cover (100% constancy)
Potential	
Coyote Willow (*Salix exigua* var. *exigua*)	82% average cover
Douglas Fir/Red-Osier Dogwood Habitat Type	
Narrowleaf Cottonwood (*Populus angustifolia*)	50% average cover (9% constancy) = 5
Quaking Aspen (*Populus tremuloides*)	21% average cover (30% constancy) = 6
Black Cottonwood (*Populus trichocarpa*)	44% average cover (43% constancy) = 19
Douglas fir (*Psuedotsuga menziesii*)	25% average cover (100% constancy) = 25
Red-osier dogwood (*Cornus stolonifera*)	11% average cover (43% constancy) = 5
Common chokecherry (*Prunus virginiana*)	10% average cover (43% constancy) = 4
	Total weighted average cover = 64%
Ponderosa Pine/Common Chokecherry Habitat Type	
Ponderosa pine (*Pinus ponderosa*)	27% average cover (100% constancy) = 27
Green Ash (*Fraxinus pennssylvanica*)	4% average cover (19% constancy) = 0.8
Common chokecherry (*Prunus virginiana*)	30% average cover (100% constancy) = 30
	Total weighted average cover = 58%

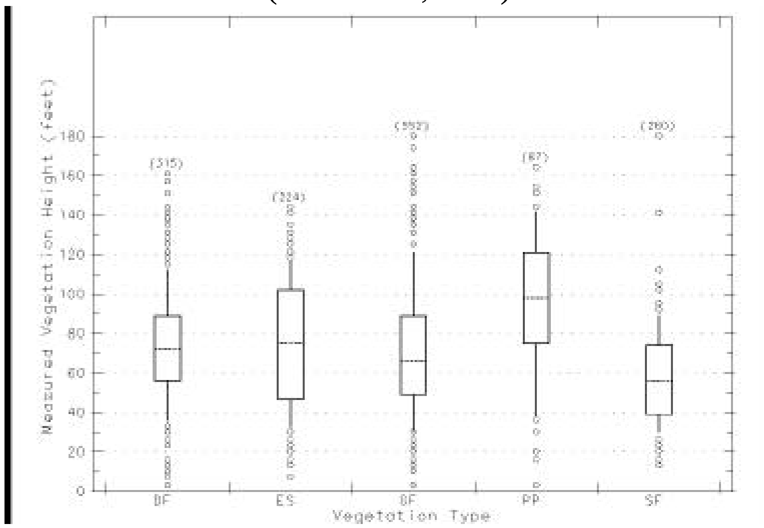
Height of Potential Natural Vegetation

Nationally recognized (Forest Service Fire Effects Information System) mature vegetation heights for each of these species are presented in **Table 23**. To provide a "reality check," tree heights presented in Table 23 were compared to tree height values measured within the Nez Perce National Forest (NPNF) (**Figure 4**), and they are reasonably comparable (i.e. the mature heights fall within the range of measured heights on the Forest). It is important to note that current conditions illustrated in **Figure 4** were developed from data that included all age classes (i.e., young to mature), and included "disturbed" vegetation, not just mature trees. Mature tree heights were chosen for the remainder of the analysis to provide an addition to the margin of safety.

Table 23. Mature Vegetation Height Condition
(from the USDA Forest Service Fire Effects Information System (www . fs.fed.us/database/feis))

Vegetation Type	Height Range (ft)	Suggested Value
Grand Fir (*Abies grandis*)	131 to 164	148
Engelmann Spruce (*Picea engelmannii*)	45 to 130	88
Douglas Fir (*Psuedotsuga menziesii*)	100 to 120 (var. glauca, R. Mnt. Interior).	110
Subalpine Fir (*Abies lasiocarpa*)	60 to 100	80
Ponderosa Pine (*Pinus ponderosa*)	90 to 130 (var. ponderosa, Pacific Ponderosa Pine).	110
Rocky Mountain Maple (*Acer glabrum*)	20 to 30	25
Red-osier Dogwood (*Cornus stolonifera* or *C. sericea*)	3 to 19	11
Chokecherry (*Prunus virginiana*)	3 to 19.5	12
Serviceberry (*Amelanchier alnifolia*)	3 to 26	15
Paper Birch (*Betula Papyrifera*)	70 to 80	75
Western Larch (*Larix Occidentalis*)	164 ("Typical")	164
Black Cottonwood (*Popuus trichocarpa*)	100 ("Common")	100
Mountain Alder (*Alnus incana*)	6 to 15	11
Whitebark Pine (*Pinus albicaulis*)	50 to 70	60
Lodgepole pine (*Pinus contorta*)	50 – 100 (var. latifolia)	75
Narrowleaf Cottonwood (*Populus angustifolia*)	60	60
Quaking Aspen (*Populus tremuloides*)	< 48	40
Green Ash (*Fraxinus pennssylvanica*)	66	66
Coyote Willow (*Salix exigua* var. *exigua*)	6 to 12	8

Figure 4. Measured Tree Heights in the Nez Perce National Forest (1989 – 1993)
(USFS Data, 2002)



Estimated Community Composition of Potential Natural Vegetation

Community composition dimensions for each of the Habitat Groups are presented in Table 24. This table shows the process by which dimensions for a composite shade producing vegetation are attained for each habitat type. The weighted average canopy cover from Table 22 is shown in the first column of numbers. These cover values for each species in the habitat type are converted to a relative proportion of the total cover in the second column of numbers. Vegetation heights from Table 23 are shown in the third column of numbers, and those heights are weighted based on relative cover to form the fourth column of numbers. Estimated overhang for the entire habitat type is then calculated as 10% of the total weighted height of trees (33% for shrubs). Thus, for example, the Grand fir type has a weighted average cover of 76%, a weighted height of 98 feet, and an estimated overhang of 9.8 feet. These values are used in the effective shade curve analysis to represent the composite shading potential of the all the species in the habitat type.

The average tree height condition within mature tree height range was included in subsequent effective shade analysis. Height values for several "Shrub" species were estimated in the upper range of expected values, except for the Meadow Habitat Group (i.e., Coyote Willow), which was allocated at the average value within the mature range of heights.

Table 24. Potential Natural Overstory Vegetation Composition along Crooked Creek						
PNOV Habitat Type	Overstory species	Weighted Ave. Canopy Cover (%)	Relative Proportion of Total (%)	Vegetation Height (ft)	Weighted Height (ft) (Proportions * Height)	Estimated Overhang (ft)
Grand Fir/Lady Fern	Grand Fir	30	39	148	58	
	Spruce	12	16	88	14	
	Douglas Fir	5	7	110	7	
	Rocky Mountain Maple	13	17	25	4	
	Subalpine Fir	0.6	1	80	1	
	Paper Birch	0.6	1	75	1	
	Western Larch	5	7	164	11	
	Black Cottonwood	0.8	1	100	1	
	Mountain Alder	9	12	11	1	
	Composite	**76**			**98**	**9.8**
Subalpine Fir/Bluejoint Reedgrass	Subalpine Fir	32	40	80	32	
	Spruce	38	48	88	42	
	Lodgepole Pine	9	11	75	8	
	Whitebark Pine	0.2	0	60	0.2	
	Mountain Alder	0.4	1	11	0.1	
	Composite	**80**			**83**	**8.3**
Meadow	Coyote Willow	82	100	8	8	2.6
	Tufted Hairgrass	42	100	2	2	0.8
Douglas Fir/Red-Osier Dogwood	Douglas fir	25	39	110	43	
	Red-Osier Dogwood	5	8	11	1	
	Common Chokecherry	4	6	12	1	
	Narrowleaf Cottonwood	5	8	60	5	
	Quaking Aspen	6	9	40	4	
	Black Cottonwood	19	30	100	30	
	Composite	**64**			**83**	**8.3**
Ponderosa Pine/Common Chockcherry	Ponderosa Pine	27	47	110	51	
	Green Ash	0.8	1	66	1	
	Common Chokecherry	30	52	12	6	
	Composite	**58**			**59**	**5.9**

Shade Curves - Surrogate Measure

As presented earlier in this document, stream surface shade production is a function of geometric relationships between the sun's position and topography, near stream land cover and channel features. Stream surface shade at estimated potential natural vegetation community composition conditions (see Table 24 above) was simulated using computer software developed by Oregon Department of Environmental Quality[8].

Over the years, the term shade has been used in several contexts, including its components such as shade angle or shade density. For purposes of the shade curves, shade is defined as the percent reduction of potential direct beam solar radiation load delivered to the water surface. Thus, the role of effective shade in this TMDL is to prevent or reduce heating by solar radiation and serve as a linear translator to the solar loading.

The non-point source assessment demonstrates that stream temperatures warm as a result of increased solar radiation loads, due to anthropogenic disturbance to near stream vegetation and channel morphology. A loading capacity for radiant heat energy (i.e., incoming solar radiation) can be used to define a reduction target that forms the basis for identifying a surrogate. The specific surrogate used is percent effective shade (expressed as the percent reduction in potential solar radiation load delivered to the water surface). The solar radiation loading capacity is translated directly (linearly) by effective solar loading. The definition of effective shade allows direct measurement of the solar radiation loading capacity.

As noted in Table 21, channel width is an important component of shade production. That is, it becomes progressively more difficult to shade a river with a particular vegetation conditions, as the channel width increases. Channel width is best described as the “Near-Stream Disturbance Zone” (NSDZ), which is defined for purposes of the shade curve as the width between shade-producing near-stream vegetation. Where near-stream vegetation was absent, the near-stream boundary was used, as defined as armored stream banks or where the near-stream zone is unsuitable for vegetation growth due to external factors (i.e., roads, railways, buildings, etc.). It is important to note that bankfull width and NSDZ are often similar.

Factors that affect water temperature are interrelated. The surrogate measures (percent effective shade and channel width) rely on restoring/protecting riparian vegetation to increase stream surface shade levels and reducing the NSDZ width (by reducing stream bank erosion and stabilizing channels), which will reduce the surface area of the stream exposed to radiant energy. Shade is more effective on narrow streams than on wider streams given the same flow of water at a given point because shadows cast by trees cover a greater percentage of the stream surface. Effective shade screens the water’s surface from direct rays of the sun. Highly shaded streams often experience cooler stream temperatures due to reduced input of solar energy.

8 This shade calculator has been used by Oregon Department of Environmental Quality and Washington Department of Ecology during the development of temperature TMDLs during the past several years.

Effective shade curves were developed using vegetation conditions for Crooked Creek, as described in Table 24 (Figures 5 through 10). These curves are independent of location on the stream within a particular habitat type. Because effective shade is a measure of energy, a load in terms of Langleys per day can be directly calculated from this value. Given a measured or estimated channel width (e.g., NSDZ) and the directional aspect of a stream, the percent effective shade or the solar radiation loading can be estimated from the following graphs. It is best to have site-specific measurements of channel width and stream aspect (and vegetation for that matter) to produce an effective shade estimate at a specific location. In the case of Crooked Creek, because the site-specific information is based on interpretations of relatively coarse GIS-based information, the effective shade estimates are not precise for a particular location. To improve the estimates, actual channel width and aspect data would have to be collected in the field at some interval. The more frequent the interval, the more accurate the estimate.

As an example of how the effective shade curve works, let's say you have a location on a stream in a Grand fir habitat type where the aspect is NE (45^o), and the channel width (NSDZ) is five meters. Figure 5 shows that the squares line representing 45^o from North intersects the 5-m NSDZ grid where solar loading is about 58 Langleys/day and the potential effective shade is approximately 90%. In a similar stream in the same vegetation type, but with a 15-m wide channel, the potential effective shade is less than 75% (~156 ly/day solar loading). Actual effective shade may be less that these values at these stream sites due to disturbance. A solar pathfinder set up at the site could measure actual effective shade. Comparisons between actual and potential effective shade demonstrate how far from the target is the existing stream condition.

For the meadow habitat types (Figures 7 and 8), the shape of the curve is much different than forest based curves. Due to much lower vegetation height, a stream with a particular aspect will show rapid and substantial decreases in potential effective shade as the channel width increases. This is due to the fact that lower meadow vegetation cannot shade wide streams as well as trees can.

Figure 5. Effective Shade Curve – Application in Grand Fir/Lady Fern Habitat Type

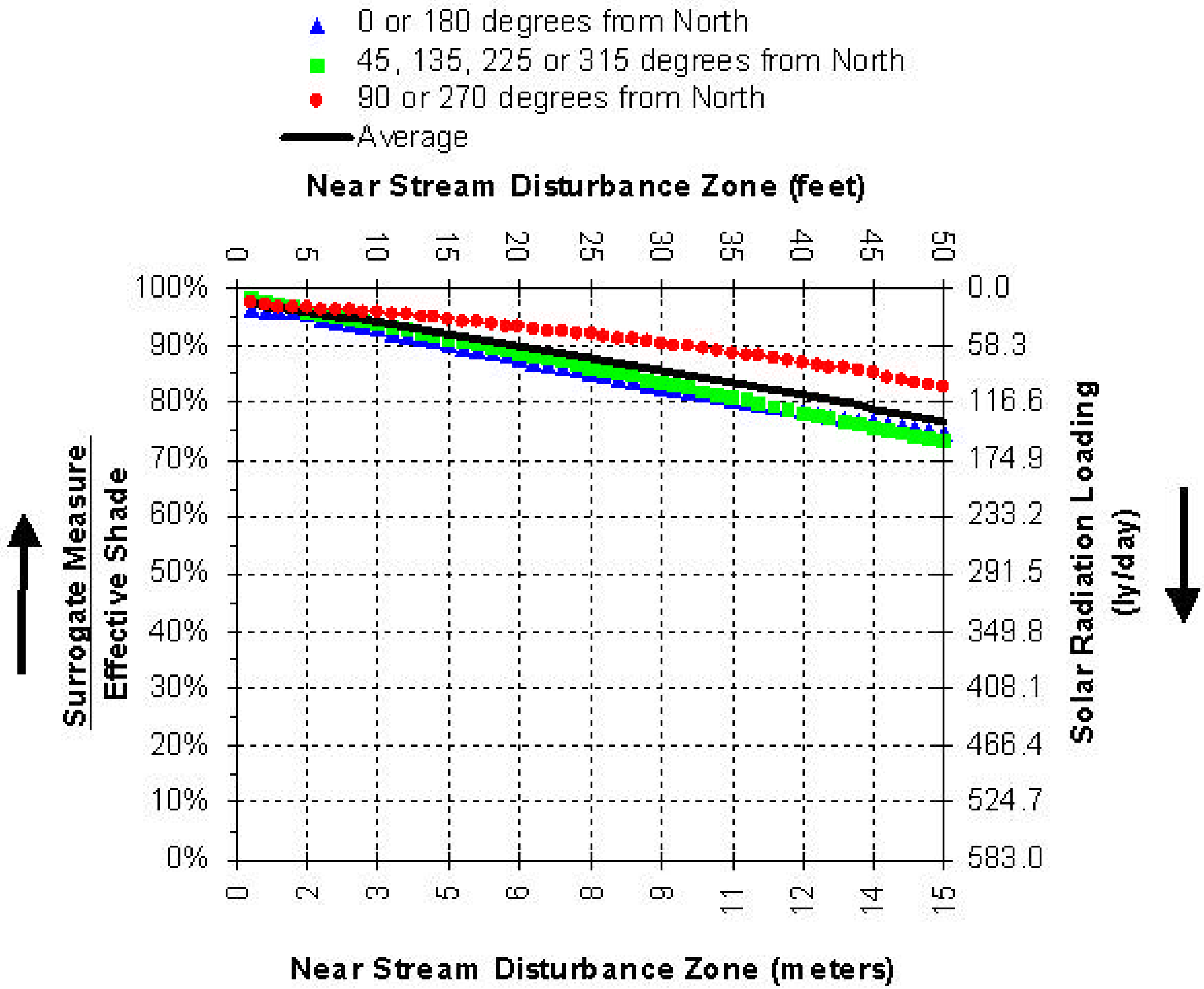


Figure 6. Effective Shade Curve – Application in Subalpine Fir/Bluejoint Reedgrass Habitat Type

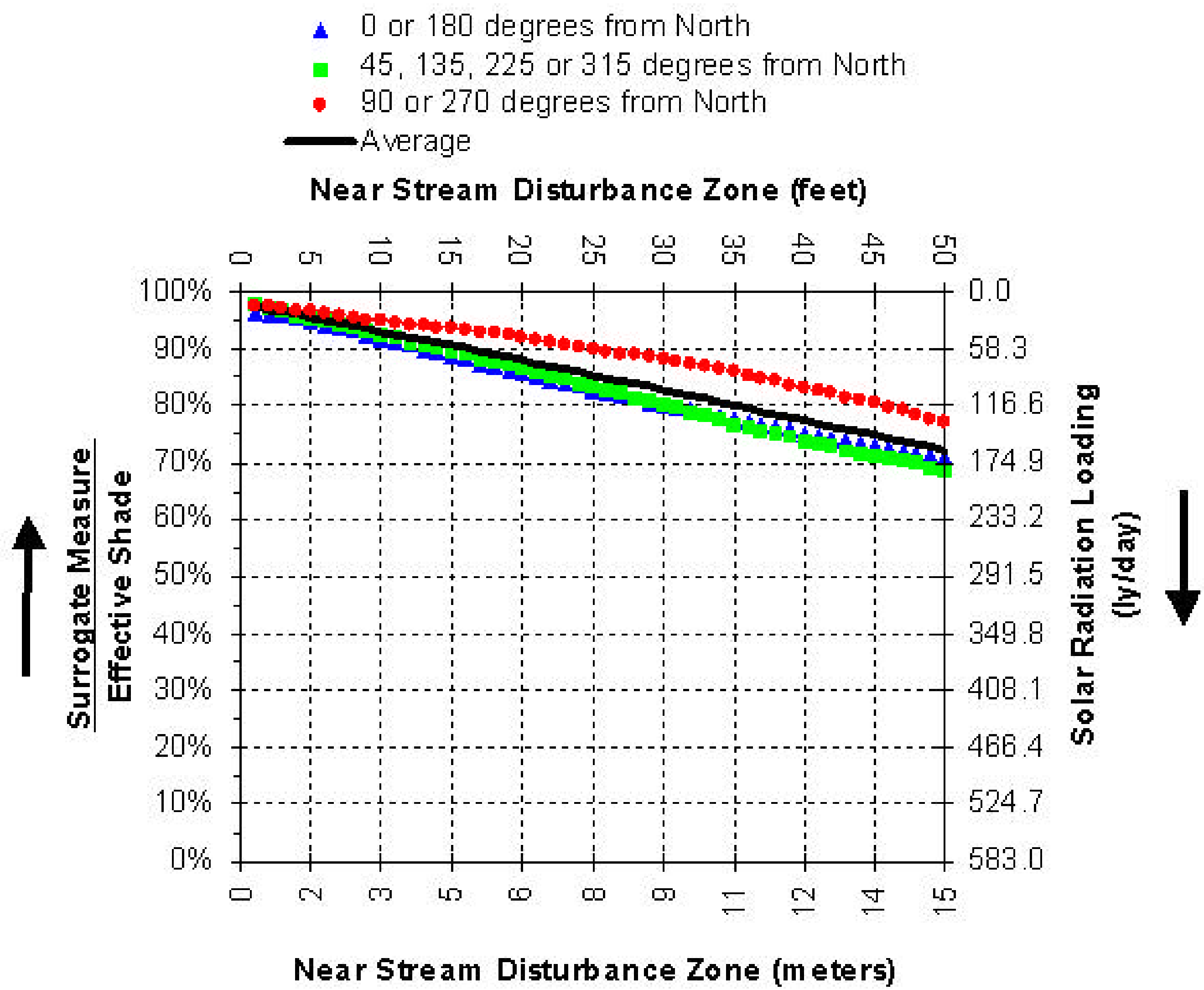


Figure 7. Effective Shade Curve – Application in Meadow Habitat Type - Coyote Willow

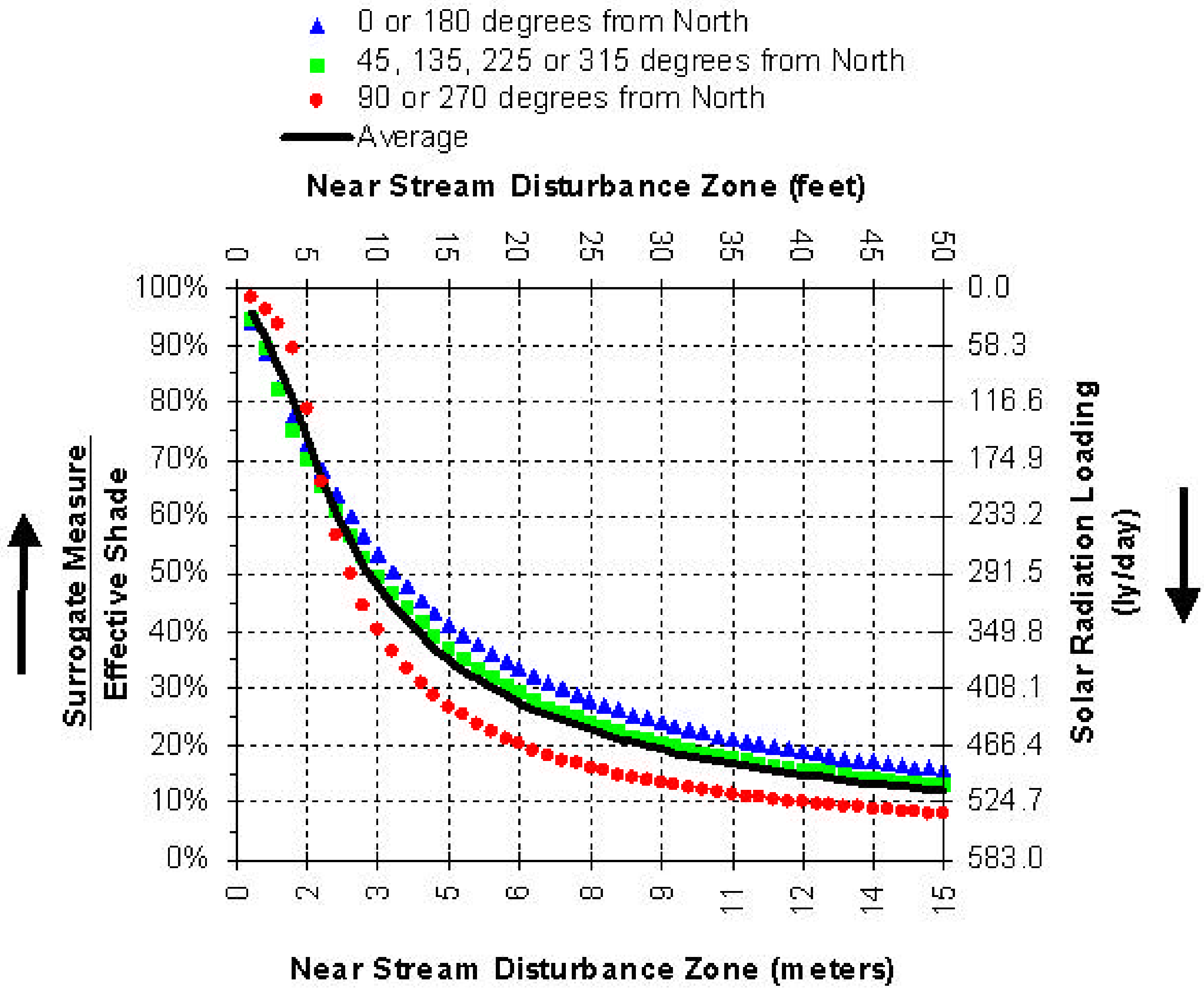


Figure 8. Effective Shade Curve – Application in Meadow Habitat Type – Tufted Hairgrass

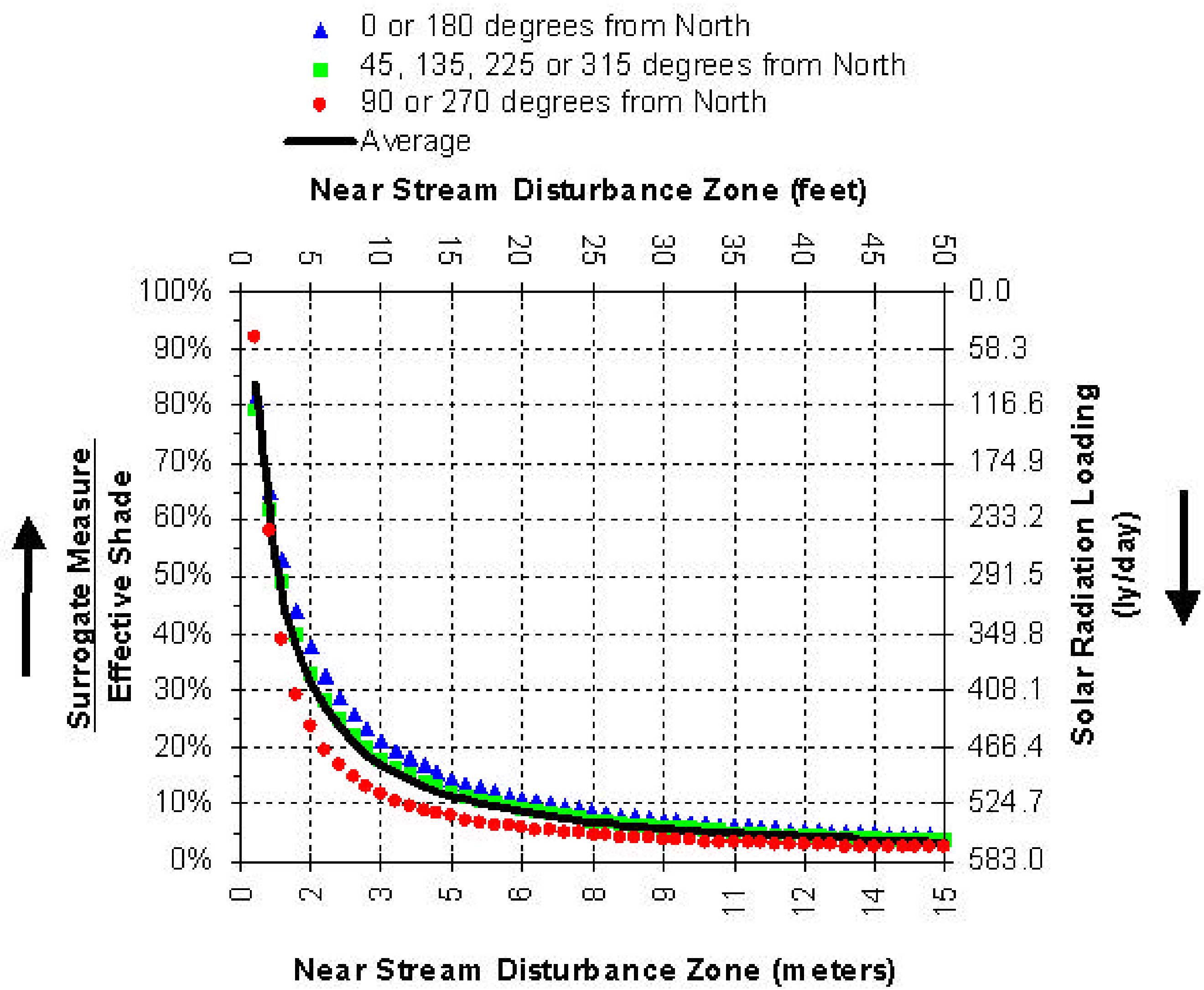


Figure 9. Effective Shade Curve – Application in Douglas Fir / Red-osier Dogwood Habitat Type

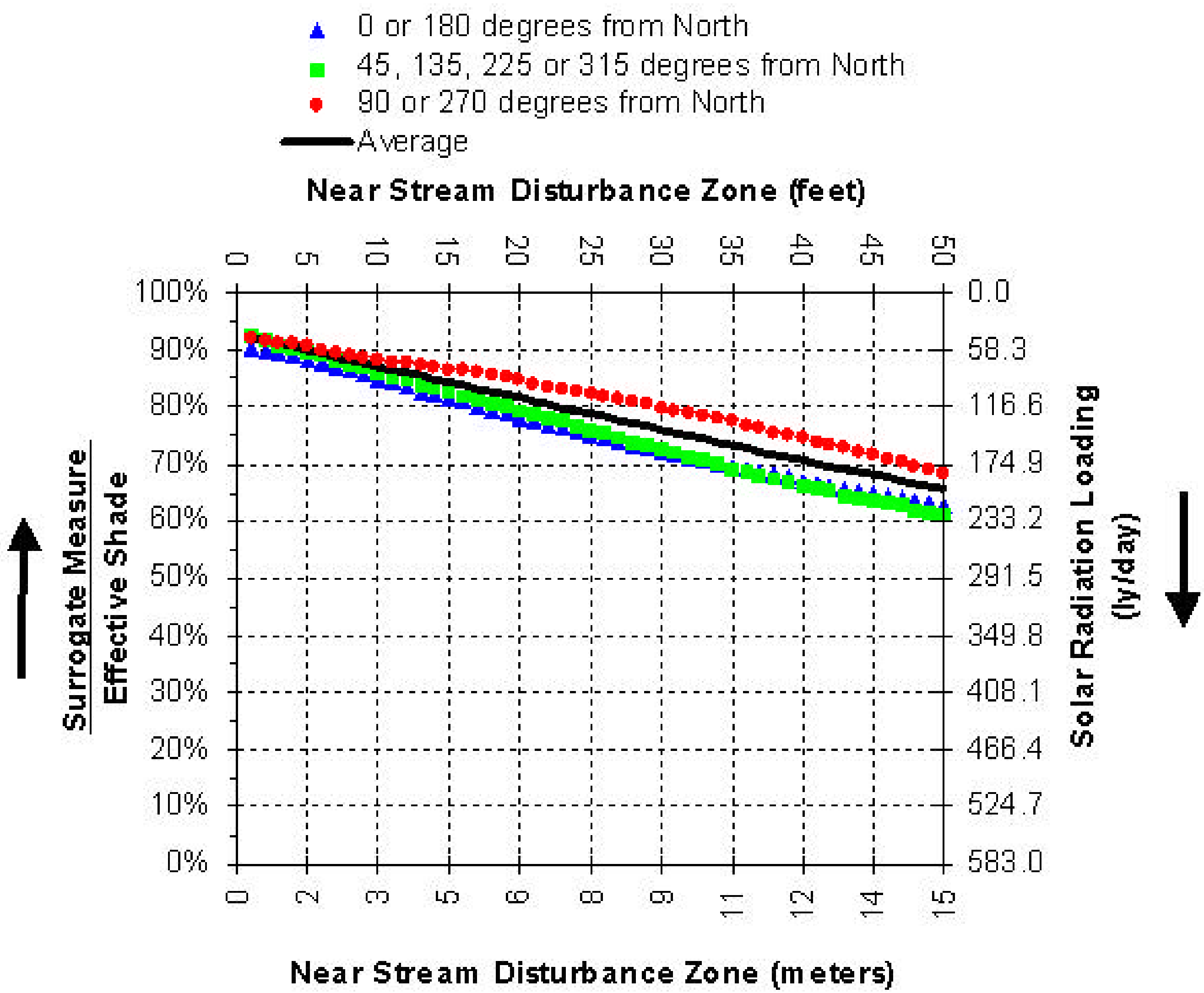
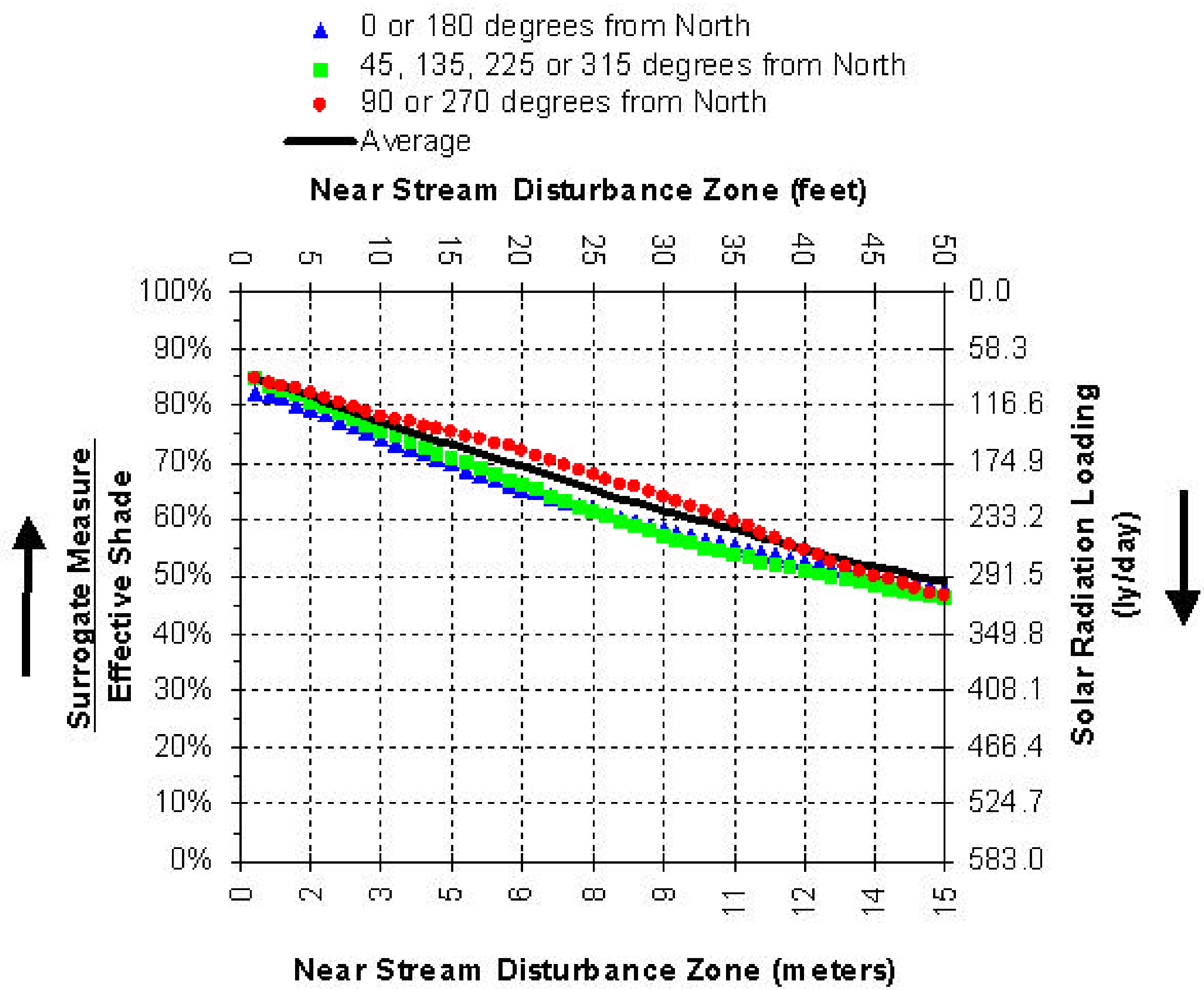


Figure 10. Effective Shade Curve – Application in Ponderosa Pine/Common Chokecherry Habitat Type



Effective Shade and Temperature - Role of Local Condition

The local features affect the potential effective shade conditions along a stream. Along with the channel and vegetation features (illustrated above), local geographic features affect the potential stream shade conditions. For example, stream elevation is used for calculating solar radiation loading and solar position. In addition, stream aspect and topographic shade partly determine the effectiveness of vegetation in providing shade to the stream surface. For these reasons, stream elevation, aspect and topographic shade angle were sampled for Crooked Creek from a 30-meter digital elevation models (DEMs) (see image to right) at 100 foot intervals. Sampling was accomplished using GIS tools developed for this specific application (www deq.state.or.us/wq /TMDLs/ WQAnalTools.htm). Sampling landscape features at a high resolution, from available data sets, enables a detailed evaluation of additional landscape conditions that, in addition to near stream vegetation conditions, may be influencing effective shade conditions along Crooked Creek, and ultimately affecting the temperature of the river. Both sampled elevation and gradient data are plotted for Crooked Creek in Figure 11. Topographic Shade Angles calculated from the DEM are presented in Figure 12. Stream Aspect is presented in Figure 13. Finally, stream valley bottom widths, defined as a maximum one meter elevation increase from the stream bottom (defined as a 1:24K stream layer), are presented in Figure 14.

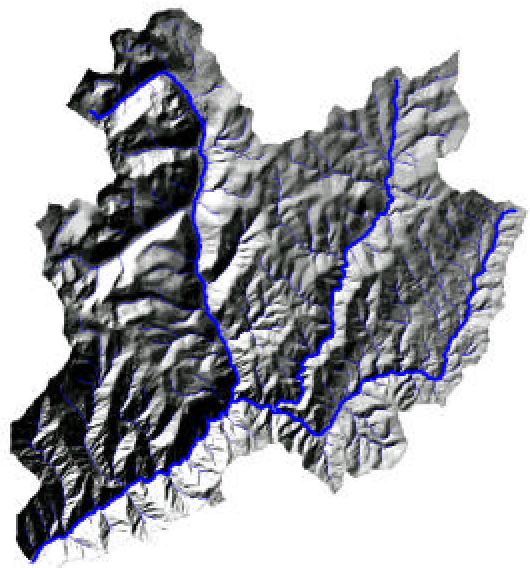


Figure 11. Stream Elevation and Stream Gradient along Crooked Creek.

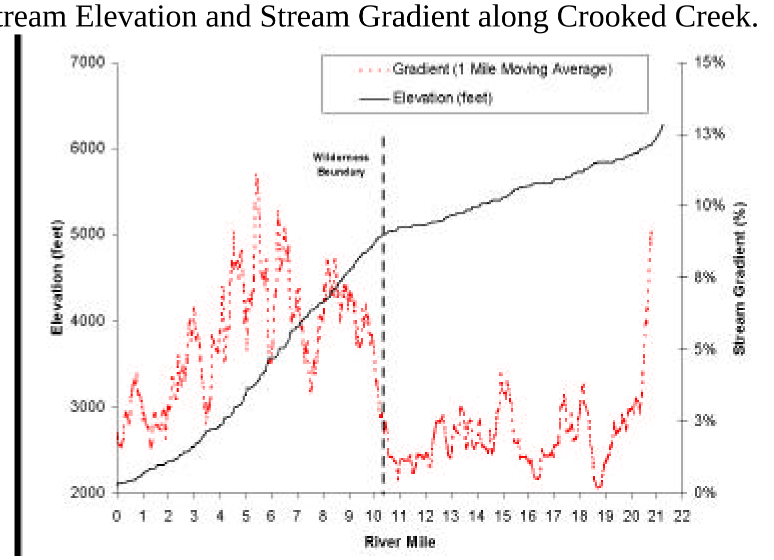


Figure 12. Topographic Shade Angle along Crooked Creek.

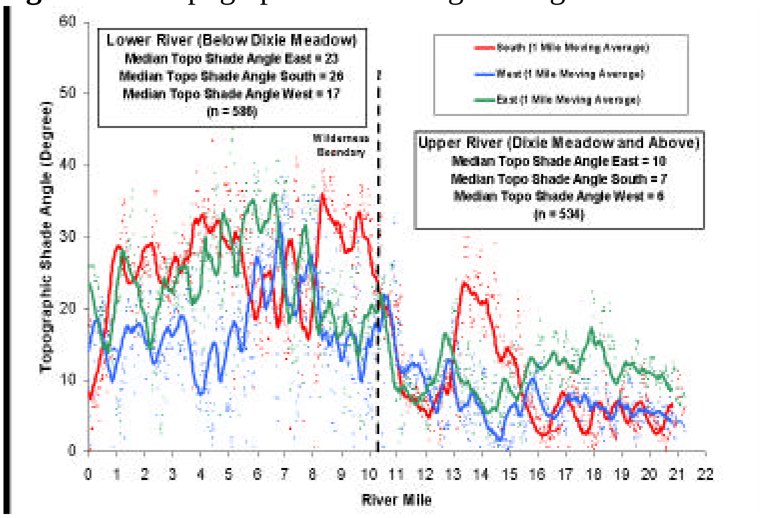


Figure 13. Stream Aspect along Crooked Creek.

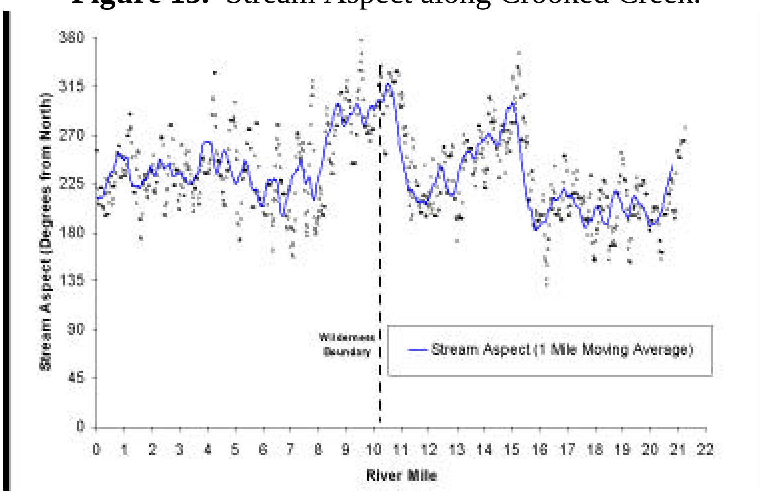
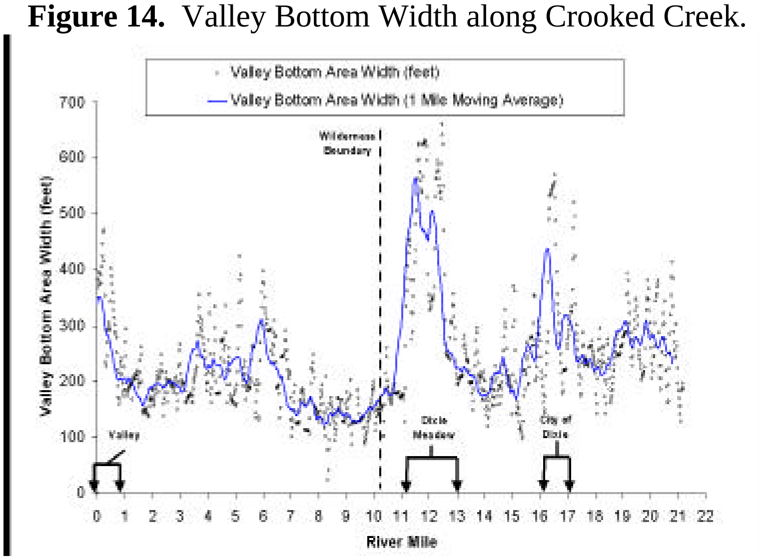


Figure 14. Valley Bottom Width along Crooked Creek.



These figures illustrate that Crooked Creek travels through several distinct areas, from upper reaches that experience relatively low gradients and topographic angles, downstream to an area with very high gradients and topographic angles. In addition, the upper reaches of the river travel through areas that are much less confined than in the lower reaches of the river (as defined by the rough estimates of valley bottom width illustrated in Figure14). This is especially evident within Dixie Meadow. All of these factors will affect the ability of the near stream vegetation to provide shade to the river, as well as determine the particular water temperature response from the energy balance affecting the river.

Estimate of Effective Shade Along Crooked Creek

An estimation of effective shade conditions for Crooked Creek was developed using physical information illustrated above, along with detailed vegetation conditions presented in Table 24. It is important to note that the resulting effective shade profile developed from this effort utilize the same algorithms used to create the shade curves (Figures 5 though 10), however this effort will contain a spatial component.

Estimate of Bankfull Channel Width

The only factor **not** developed from the work presented above is channel width (i.e., NSDZ or Bankfull Width). Accordingly, this parameter must be estimated from available information. Leopold et. al (1964) proposed that channel width tends to increase linearly with increases in drainage area. Rosgen (1996) reported that bankfull width can be estimated as a function of width to depth ratio and cross-sectional area.

$$BFW = \sqrt{W:D \cdot A_{bf}}$$

Where: A_{bf} is the Bankfull Cross-Sectional Area (ft^2)
W:D is the width to depth ratio

Figure 15 illustrates the regional curve for bankfull cross-sectional area (A_{bf}) and drainage area (DA) in the Upper Salmon River Basin (USGS Professional Paper 870-A). As noted above, Crooked Creek was segmented by vegetation habitat types (see Table 2). GIS was used to calculate the upstream contributing area (DA) at the lower end of each of these unique habitat types (Figure 16). Upstream contributing areas between these locations were estimated through interpolation. Bankfull Cross-Sectional Area was then estimated using the relationship presented in Figure 15. Width to depth ratio values were assigned values derived from published ranges for level I stream types (Rosgen 1996). Target Bankfull Width values for each of these Rosgen Level I Stream Types were estimated using the equation listed above (Figure 17). Target values developed during this exercise were used to develop channel width conditions used in Effective Shade Calculations.

Level I Stream Type	Width to Depth (W:D)
A	8
B	19
C	30
D	N/A
E	7
F	28
G	8

Figure 15. Bankfull Cross-Sectional Area as a function of Drainage Area in the Upper Salmon River Basin, Idaho (Emmett, 1975)

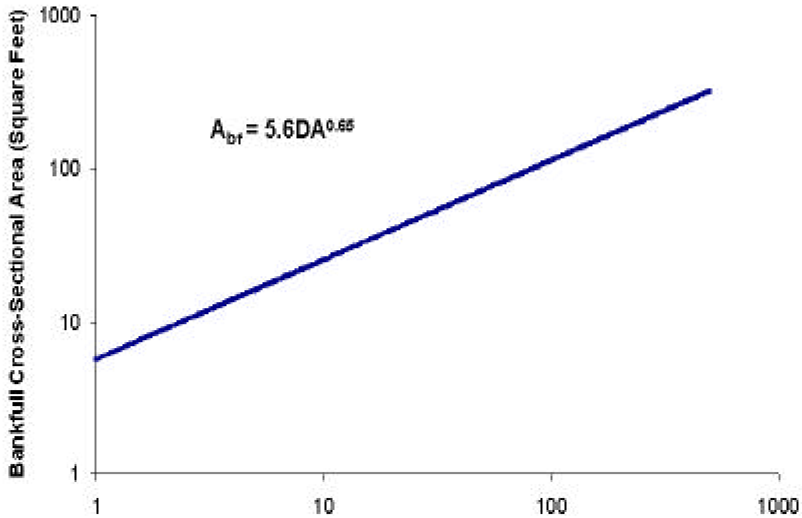


Figure 16. Upstream Contributing Areas within Crooked Creek

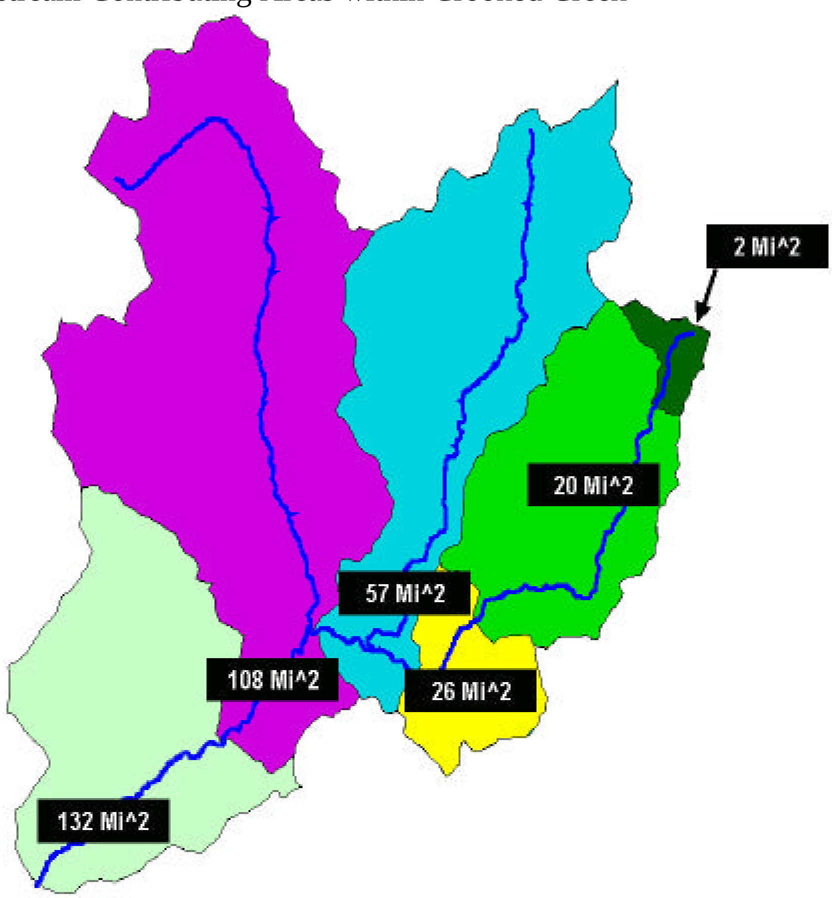
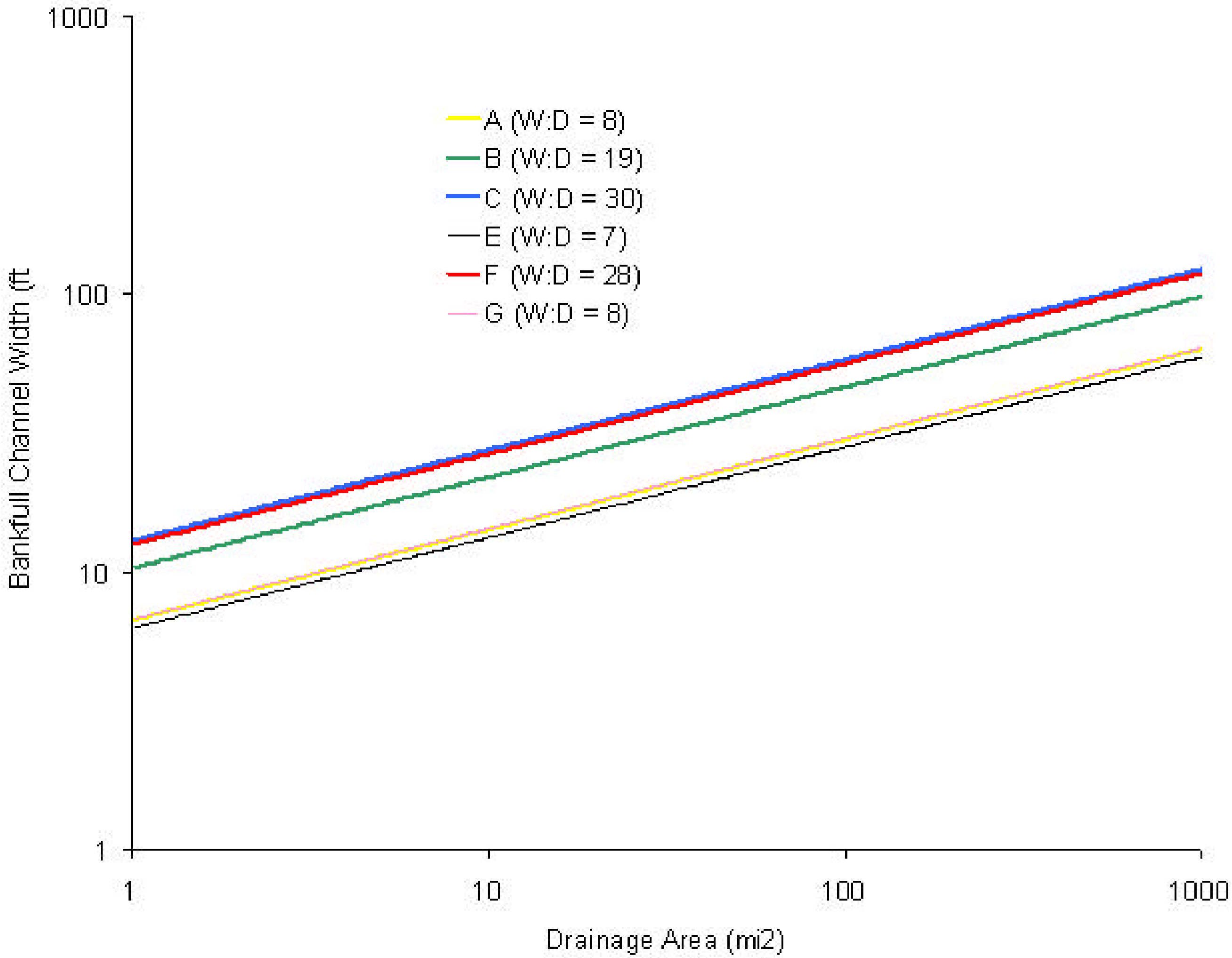


Figure 17. Bankfull Width as a Function of Width to Depth Ratio and Drainage Area



Accordingly, Rosgen level I classification can be used to estimate approximate bankfull width conditions through applying the equation listed above. Rough estimates of Rosgen level I classification for Crooked Creek were estimated from gradient information (Figure 11), and local knowledge. Figure 18 illustrates the approximate bankfull width conditions that would be expected as a potential condition along Crooked Creek. This information was used, along with aspect (Figure 13), topographic shade angle (Figure 14), and elevation (Figure 12) to calculate expected potential shade when applying vegetation communities along Crooked Creek (Table 24) (Figure 19).

Figure 18. Estimated Bankfull Widths in Crooked Creek

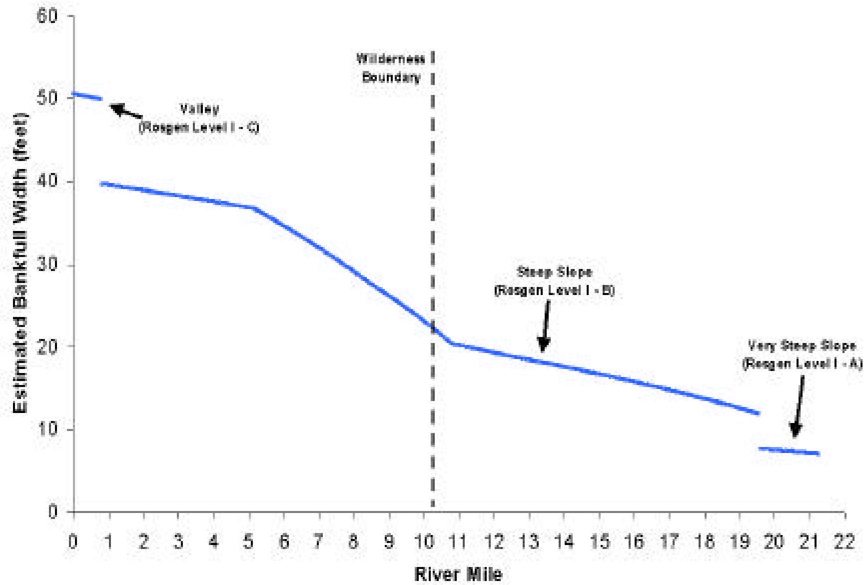
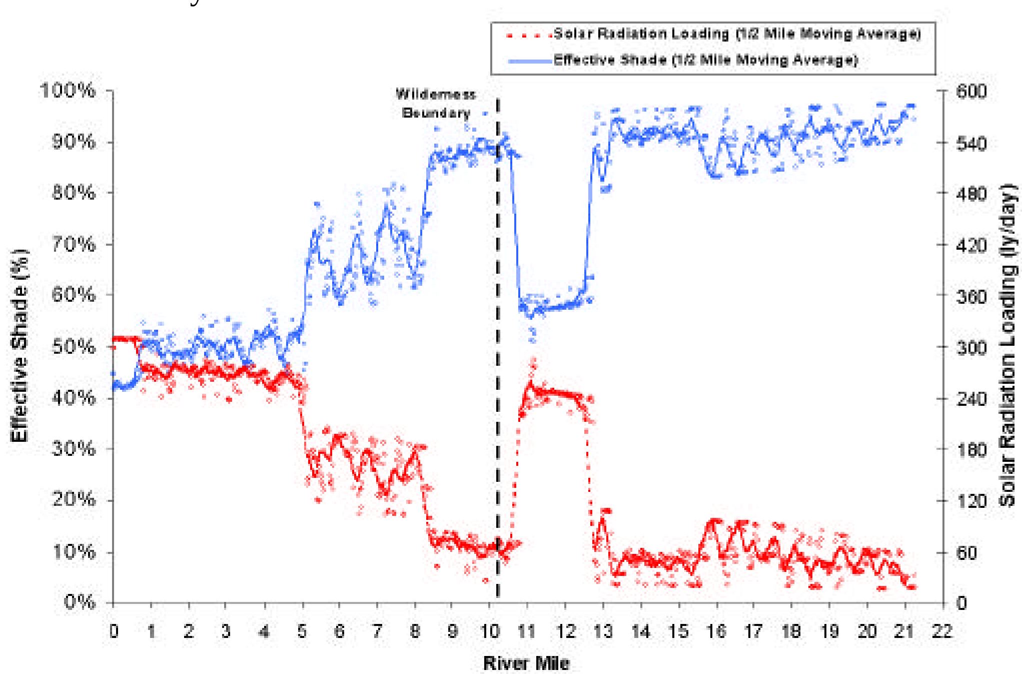


Figure 19. Estimated System Potential Effective Shade in Crooked Creek



LOADING CAPACITIES

Crooked Creek, as it advances down a steep canyon towards the Salmon River, becomes increasingly exposed to hotter, drier conditions and a change in vegetation communities from cold forests to dry forests, and eventually to shrub or grass dominated communities. Using the shade curves in combination with GIS-based local condition information, we have estimated the effective shade under potential natural vegetation to vary from approximately 95% in the headwaters to 40% at the mouth of the stream (Figure 19). The potential effective shade of 85 to 95% in the upper reaches coincides with communities dominated by cold forest conifers (subalpine fir and grand fir). In the lower half of the stream, forest community types are more typical of dry forests dominated by ponderosa pine and Douglas fir. Potential natural vegetation in the lower reaches has slightly lower effective shade from 50% to 80%. Additionally, the large meadow complex near the Dixie Work Center and airstrip would have an effective shade under potential natural vegetation (coyote willow meadow) of approximately 58%.

Figure 19 also presents the thermal loading to the stream under these effective shade scenarios. Thus, the loading capacity of the stream is represented by the red line in Figure 19, and varies from less than 60 Langleys/day in the headwaters to as much as 300 Langleys/day at the mouth of Crooked Creek in the Salmon River canyon. The meadow area near the airstrip and Dixie Work Center has a loading capacity of about 240 Langleys/day. As Crooked Creek turns southwest and begins its decent into the Salmon River canyon, the loading capacity decreases to 120 to 180 Langleys/day for several miles, then increases to 240 –300 Langleys/day.

WASTELOAD ALLOCATION

There are no permitted point sources within the Crooked Creek drainage, therefore there is no wasteload allocation for thermal loading to Crooked Creek.

LOAD ALLOCATION

Because the goal of this TMDL is to achieve a natural temperature regime to reduce stream temperatures as far as they will go, there is essentially no load allocation. The entire loading capacity of the stream is dedicated to achieving a natural condition as much as possible. Thus, the loading capacity presented in Figure 19 is equal to the natural background load. There is no thermal load that is dedicated to a nonpoint source activity.

TARGETS

To determine existing condition in the absence of solar pathfinder data, actual canopy coverage for Crooked Creek was visually estimated from 1996 aerial photographs at more or less 200-feet elevation intervals from the mouth to the headwaters. Table 25 shows these canopy estimates compared to those effective shade targets determined by the model. Unfortunately, stream segment intervals in Table 25 are not the same as river mile segments used in the effective shade modeling above. Rough comparisons to river mile are provided for some elevational intervals in Table 25.

Table 25. Canopy coverage estimates for 25 stream segments on Crooked Creek. The dashed line indicates the location of the Gospel Hump Wilderness boundary. (RM = river mile.)

Stream Segment Number	Approximate River Mile	Segment Lowest Elevation (feet)	Aerial Photo Existing Cover (%)	Potential Effective Shade (%)	Difference Between Existing and Target Cover (%)
1(Mouth)	RM 0	2080	50	50	0
2	RM 1.1	2200	40	50	10
3	RM 2.5	2400	40	50	10
4	RM 3.4	2600	40	50	10
5	RM 4	2800	20	50	30
6	RM 4.8	3000	20	50	30
7	RM 5.2	3200	40	60-75	20-35
8	RM 5.7	3400	30	60-75	30-45
9	RM 6.2	3600	30	60-75	30-45
10	RM 6.6	3800	30	60-75	30-45
11	RM 7	4000	50	60-75	10-25
12	RM 7.8	4200	50	60-75	10-25
13	RM 8.2	4400	50	60-75	10-25
14	RM 8.8	4600	50	80-90	30-40
15 (Wilderness)	RM 9.4	4800	60	80-90	20-30
16	RM10	5000	60	85-90	25-30
17	RM 10.6	5060	20	60	40*
18	RM 12.6	5200	40	60	20
19	RM 14.5	5400	50	90-95	40-45*
20	RM 15.7	5560	0	85-90	85-90*
21	RM 16.4	5600	20	85-90	65-70*
22	RM 18.2	5800	20	90-95	70-75*
23	RM 18.7	5840	60	90-95	30-35
24	RM 19.3	5880	70	90-95	20-25
25 (Headwaters)	RM 20	6000	70	90-95	20-25

*Problem Areas – those segments in need of the most rehabilitation.

To identify problem areas, the difference between the target effective shade and the existing stream canopy cover were examined. Although existing canopy cover estimated from aerial photos is not the same as effective shade, the difference between the two estimates serves as a screening tool for highlighting problem areas along the creek.

The areas in need of the most restoration of vegetation are based on the difference between these two percentages. The larger the difference, the greater the need for restoration. Increases in riparian and valley canopy cover should have a concomitant increase in effective shade and a decrease in solar radiation loading consistent with the model, and thus, a decrease in water temperature. This is a crude estimate of problem areas. In order to be more accurate, current effective shade should be measured in the field. Headwaters of Crooked Creek (above Dixie) shows a difference in values from 20 to 35. Further down stream, the difference between target effective shade values and existing cover in the upper segments (Dixie to the meadow), those most impacted by legacy mining and current development, are from 40 to 90. In the meadow itself, the difference is 40 assuming coyote willow returned to its full potential. Wilderness area segments (middle and lower) show a 10 to 45 range in value differences.

In addition to areas with reduced canopy coverage, Crooked Creek likely has an increased width-to-depth ratio as a result of dredge mining rearranging the stream, increased hydraulic loading, and posibbly other riparian activities that have lead to downcutting and widening of the channel. Figure 18 suggests that for this size of stream, bankfull width should vary from less than 10 feet wide in the headwaters (Rosgen Level 1-A) to approximately 20 feet wide before the wilderness boundary (Rosgen Level 1-B. DEQ has measured bankfull width of Crooked Creek at two locations within this upper half of the stream. The first site near RM 14 had an average bankfull width of 21 feet (based on three transects). This value is near the normal bankfull width of 18 feet predicted by Figure 18. However, the second site near RM 11 had an average bankfull width of 32 feet, a third greater than the predicted 20 feet wide in Figure 18. Bankfull width data collected by the Forest Service showed widths averaging less than 5 feet above the town of Dixie, 18 feet below Dixie, and 62 feet near the mouth. Of these three, the latter two (18 and 62 feet) are slightly elevated. These data, although limited, suggest that perhaps the stream widens a little too much through the large meadow near the airstrip. Maintaining or reducing bankfull widths to be consistent with Figure 18 may also prove usefull in reducing heat loads to the stream..

Canopy cover and bankfull width data suggest that the area in need of the most improvement in effective shade and channel dimensions is that area from the bottom of Dixie Meadow (RM 11) to about Nugget Gulch (RM 17), where differences between potential effective shade and existing canopy cover are greater than a value of 40.

MARGIN OF SAFETY

The margin of safety in this TMDL is implicit in the development of the potential effective shade. Effective shade is based on the hypothesis that the stream will experience a complete potential natural vegetal community along its borders all of the time. In reality, plant communities vary considerably with time as a result of natural disturbance (fire) and differential growth rates of species. To a certain extent, that is evident in the comparison of existing canopy coverage and the effective shade target for the wilderness section of Crooked Creek. Portions of this section have been exposed to wildfire in the recent past, probably resulting in less cover than is possible under potential natural vegetation. Nevertheless, there may be no greater margin of safety than achieving natural conditions.

SEASONAL VARIATION AND CRITICAL TIME PERIODS

Temperature criteria are applied to different time periods due to differences in life histories of target species and different regulatory conventions. The target species in this analysis has been spawning and rearing salmonids, especially bull trout. The spring salmonid spawning period ends July 15th, and the fall spawning period begins September 1st. These spawning periods often provide more than adequate time for spawning to actually occur. The federal bull trout criterion

($10^{o}C$ MWMT) applies during the summer months from June 1st to September 30th. Therefore, one of the lowest criteria is applied to the creek during the hottest time of the year. Considering the fact that potential natural vegetation estimations include deciduous species as well as conifers, the effective shade calculation targets the summer time period when the canopy should be at its greatest extent.

Climatic conditions vary from year to year. This variation is evidenced in the stream temperature data described above (Table 17 and 18). For example, 1994 seemed to have the highest temperature statistics and 1995 had the lowest. In Table 18, the number of days exceeding the federal bull trout criterion varies from a low of 229 days in 1997 to a high of 319 days in 1998, almost a 30% difference. The target effective shade should be consistent from year to year despite changes in climate from year to year. The majority of plant species considered are either long lived or receive their watering needs from the stream itself. The meadow is one area that may have its canopy cover more affected by drought conditions than other habitat types.

Future Implementation

The increase in stream shading specified herein will improve (reduce) water temperatures. The analysis conducted provides our best estimate, with given information and resources, of the extent to which stream temperatures can be improved through increased shading. There remains uncertainty as to whether current temperature criteria can be met throughout the length of this stream. Upon implementation of shading improvements, including possible ancillary improvements in channel dimensions and floodplain connectivity as a result of actions taken to increase shade, an evaluation will be needed of other possible actions to meet the true thermal potential of this stream.

It is important that a long-term goal of achieving potential effective shade be realized through resource management objectives. Differences between the potential effective shade and the existing cover vary from 0% to 90%, although for the majority of the stream the difference is less than 40%. All but one stream segment had less existing vegetative cover than effective shade based on potential natural vegetation (Table 25). Differences found within the wilderness area are probably the result of wildfire and to a lesser extent legacy activities. In the upper reaches of Crooked Creek, major differences (70 - 95%) occur between existing cover and potential effective shade, an area roughly corresponding to the reaches between Horse Flat Creek and the cemetery below Blane Creek.

Given the nature of the environment around upper Crooked Creek after a century of placer, dredge and lode mining, it is very unlikely that canopy coverage can be increased to such high levels without a tremendous amount of expense and time. The stream system for at least four miles would need to be rehabilitated including the creation of proper channel dynamics (including width-to-depth ratio), the addition of topsoil, and the planting of vegetation.

We recommend the land owners (Forest Service and private) attempt any reasonable effort to affect temperature in Crooked Creek including decreasing width-to-depth ratio in the stream where possible, revegetation where possible, and the control of activities likely to affect vegetative cover and channel characteristics. We also encourage the Forest Service to continue to monitor stream temperatures to see what temperature reductions are achieved, to measure existing effective shade through the use of solar pathfinders, and to take additional channel width measurements (especially where shade is measured).

REFERENCES

Abramovich, Ron, Myron Molnau, and Katherine Craine, 1998, Climates of Idaho, University of Idaho, College of Agriculture, Cooperative Extension System, 216p.

Aherns, C.D. 1991. Meteorology Today. 4th ed. West Publishing Co. St. Paul. 576p.

Alt, David D., And Donald W. Hyndman, 1989, Roadside Geology of Idaho, Mountain Press Publishing, Missoula, 393p.

Anderson, Don, 1999, Personal Communication, Regional Fisheries Manager, Idaho Department of Fish and Game, Southwest Region, McCall Office. Unrecorded telephone conversation.

BAER Team, 2000, *Burgdorf Junction Burned Area Emergency Rehabilitation (BAER) Report*, September 22, 2000, Burgdorf Junction BAER Team, Payette National Forest.

Beschta, R.L. and J. Weatherred, 1984, *A computer model for predicting stream temperature resulting from the management of streamside vegetation*, USDA Forest Service WSDG-AD-00009.

Beschta, R. L., R. E. Bilby, G. W. Brown, L. B. Holtby, and T. D. Hofstra. 1987. Stream temperature and aquatic habitat: Fisheries and forestry interactions. Pages 191-232 in E. O. Salo and T. W. Cundy, eds. *Streamside management: Forestry and fishery interaction*s. University of Washington, Institute of Forest Resources, Seattle, USA.

Bernhardt, Bruce E., Written correspondence dated February 20, 2001 submitted during the public comment period, Forest Supervisor, Nez Perce National Forest.

Boyd, M.S., 1996, *Heat Source: stream temperature prediction*, Masters thesis, Departments of Civil and Bioresource Engineering, Oregon State University, Corvallis, OR.

Clark, William, H., 2000, *Main Salmon River-Chamberlain Subbasin Assessment, Biotic Integrity (Macroinvertebrates)*, Idaho Division of Environmental Quality.

Clearwater Basin Bull Trout Technical Advisory Team, 1998, *Bull Trout Problem Assessment: Main Salmon River Basin Bull Trout Problem Assessment*.

DEQ, 1999, *Idaho Non-point Source Management Plan*, Idaho Department of Health and Welfare, Division of Environmental Quality, 103p.

Edwards, Allen L., 1984, An Introduction to Linear Regression and Correlation, 2nd Edition, W.H. Freeman and Company, New York, 206 p.

Emmett, ?., 1975, *Hydrologic evaluation of the upper Salmon River area, Idaho*, USGS, Professional Paper 870-A, U.S. Govt. Printing Office, Washington, D.C.

Ertter, Barbara and Bob Moseley, 1992, *Floristic Regions of Idaho*, Journal of the Idaho Academy of Science, 28(2): 57-70.

Gerhardt, Nick and Katherine Thompson, 1997, *Main Salmon River Tributaries Northeast Biological Opinion: Response to term and condition number four*, USDAXNez Perce National Forest.

Gerhardt, Nick, 2001, Personal Communication, Hydrologist, Nez Perce National Forest, Grangeville, ID, Unrecorded telephone conversation.

Gloss, Dave and Nick Gerhardt, 1992, *Nez Perce National Forest Watershed Condition Analysis*, USDA Forest Service, Nez Perce National Forest.

Hansen, Paul L., Robert D. Pfister, Keith Boggs, Bradley J. Cook, John Joy, and Dan K. Hinckley, 1995, *Classification and Management of Montana's Riparian and Wetland Sites*, Montana Forest and Conservation Experiment Station Misc. Pub. No. 54, School of Forestry, University of Montana, Missoula.

Hyndman, Donald W, 1989, *Formation of the northern Idaho batholith and the related mylonite of the western Idaho suture zone*, *In*: Chamberlain, V.E., Roy M. Breckenridge, and Bill Bonnichsen (eds.), 1989, Guidebook to the Geology of Northern and Western Idaho and Surrounding Area, Idaho Geological Survey Bulletin 28, University of Idaho, Moscow, 156p.

Idaho Dept. Of Commerce, 1999, County Profiles of Idaho 1999, Idaho Department of Commerce, Economic Development Division.

IDEQ, 1992, *Water Quality 305 (b) Biennial Report*.

IDEQ, 1996, 1996 *Water Body Assessment Guidance: A streams to standards process*. Idaho Department of Health and Welfare, Division of Environmental Quality. Boise.

IDEQ, 1999, *Lochsa River Subbasin Assessment (Public Comment Draft*), Prepared by Lewiston Regional Office.

IDL, 2000, *Forest Practices Cumulative Watershed Effects Process for Idaho*, Idaho Forest Practices Act, Idaho Department of Lands, March 2000.

Leopold, L.B., M.G. Wolman, and J.P. Miller, 1964, Fluvial Processes in Geomorphology, Freeman, San Francisco, 522pp.

Mays, J.D. 2000, Personal Communication, 5/2/2000, Fisheries Biologist, Elk City/Red River Ranger District, Nez Perce National Forest.

McKay, K.L., 1996, *Hidden Treasures: Historical Overview of the Dixie Mining*

District, Idaho County, Idaho, Prepared for Nez Perce National Forest under contract #43-0295-5-0172, 291p.

National Park Service, 1999, National Park Service Wild and Scenic Rivers website information (acquired on July 27, 1999).

NPNF, 1990a, *Final Environmental Impact Statement: Cove Timber Sales*, USDAXNez Perce National Forest.

NPNF, 1990b, *Final Environmental Impact Statement: Mallard Timber Sales*, USDAXNez Perce National Forest.

NPNF, 1994, *Biological Assessment: Main Salmon River Tributaries (Northeast*), USDAXNez Perce National Forest.

NPNF, 1999a, *Biological Assessment: Main Salmon River Subbasin (Little Salmon River to Sabe Creek), fish, wildlife, and plants*, USDAXNez Perce National Forest.

NPNF, 1999b, *Main Salmon River Tributaries (Northeast), 1999 Aquatic Monitoring Report to NMFS; Biological Opinion Terms and Conditions Compliance*, USDAXNez Perce National Forest, Red River Ranger District.

Oke, T.R., 1978, Boundary Layer Climates, Maethuen and Company, Ltd, London, 372pp.

Paradiso, J., 2000, *Main Salmon Basin (17060207) Data Discussion*, Nez Perce National Forest, March 7, 2000.

Park, C., 1993, *SHADOW: stream temperature management program, User's manual v.2.3*, USDA Forest Service, Pacific Northwest Region.

Payette National Forest, 1999, http://www.mccall.net/pnf August 20, 1999.

Payette Natioanl Forest, 2001, http://www.mccall.net/pnf, March 15, 2001.

PNF, 1995, *Warren Creek Stream Inventory, 1993-1995*, USDAXPayette National Forest.

PNF, 1999, *Biological assessment for the potential effects of managing the Payette National Forest in the Main Salmon River tributaries Section 7 watershed (Little Salmon River to South Fork Salmon River) on Snake River Spring/Summer Chinook Salmon, Snake River Steelhead, and Columbia River Bull Trout*, USDAXPayette National Forest.

Rosgen, D.L., 1994, *A Classification of Natural Rivers*, Catena, 22, pp. 169-199.

Rosgen, D.L., 1996, Applied River Morphology, Wildland Hydrology, Pagosa Springs, CO.

State of Idaho, 1989, *Water Quality Advisory Committee Report on Stream Segments of Concern*, Printed by Idaho Division of Environmental Quality.

State of Idaho, 1992, *Water Quality Advisory Committee Report on Stream Segments of Concern*, Printed by Idaho Division of Environmental Quality.

Steele, R., R.D. Pfister, R.A. Ryker, and J.A. Kittams, 1981, Forest Habitat Types of Central Idaho, USDAXForest Service, General Technical Report INT-114, 138p.

USFS, 1999, *Salmon River Canyon Project: Draft Environmental Impact Statement*, USDA XNorthern and Intermountain Regions (Nez Perce, Payette, Bitterroot and Salmon-Challis National Forests).

Van Vooren, Al, January 3, 2000, Personal Communication in form of written correspondence, Regional Supervisor, Idaho Department of Fish and Game, Southwest Region, Nampa Office

Zuniga, Randy, 2001, Personal Communication, hydrologist, Payette National Forest, McCall District, March 26, 2001, unrecorded telephone conversation.